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EDISON ELECTRIC CO.

SCIENTIFIC AMERICAN SUPPLEMENT. No. 1728

Entered at the Post Office of New York, N. Y., as Second Class Matter.
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Published weekly by Munn & Co. at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXVII, No. 1728. NEW YORK. FEBRUARY 13, 1909. Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

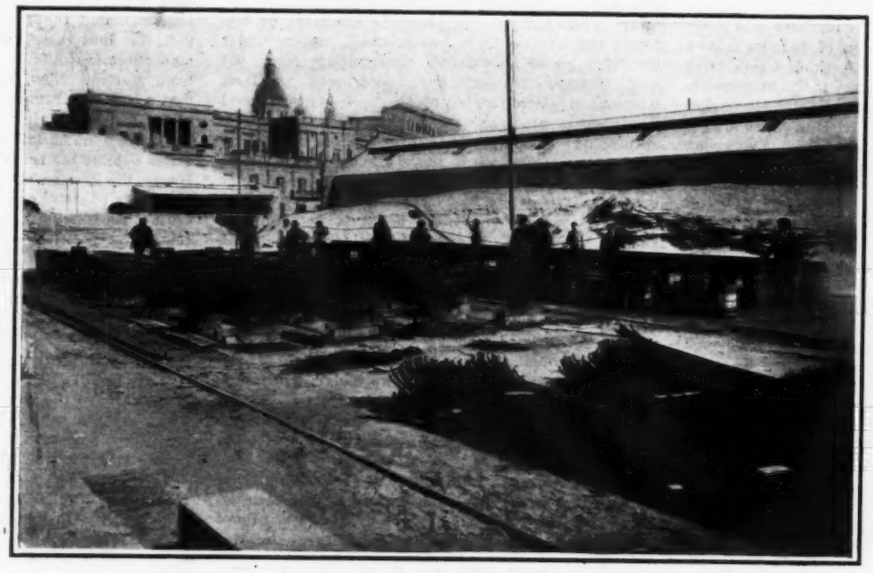
A NEW SYSTEM OF REINFORCED CONCRETE.

MR. EMILE VILLET is at present engaged in making 3,640 concrete piles at Rosario de Santa Fé (Argentina) according to a system of his own.

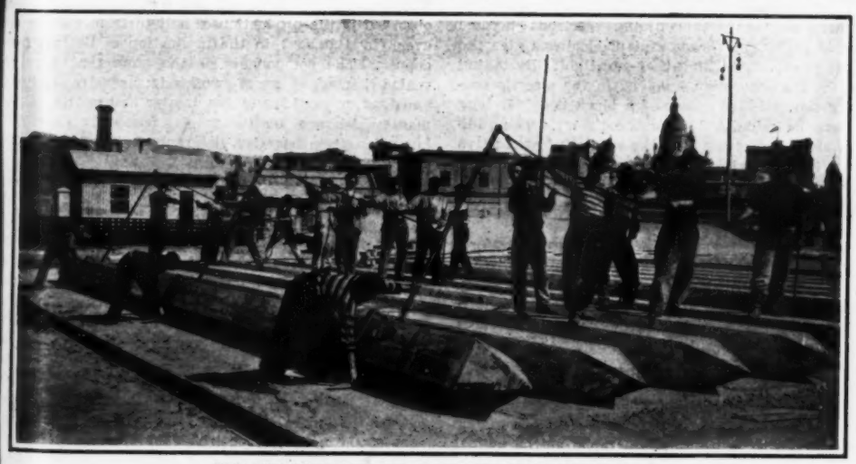
These piles take the place of the pillars on which 2,500 feet of wall for the mole now under construction will be built, the piles being driven to 22 feet below "zero." As the pressure necessary to get to solid bottom for construction purposes is more than 98 feet below water level of the Parana River, it is a constant source of danger for the workmen working in compressed air, and for this reason it was found necessary to use reinforced concrete piles in place of the pillars which it had been proposed to use in the work. Each pillar is supplanted by 35 piles of 56 feet x 1.3 feet x 1.3 feet and of an average weight of 7 tons. The length of some of these reaches up to 76 feet, and the weight to approximately 10 tons each. All the piles are driven to 20 feet below "zero," determined by the construction of the mole. The pile driving is assisted by injection, and for this purpose each pile has a hollow close to the top which serves as a tube and outlet for the water, with a pressure of about 70 pounds per square inch.

I give as an example the work done on pile No. 19 of lot 34: Date of manufacture, February 15, 1908. Transported on March 16, 1908. Driven on July 16, 1908. This pile was driven 151 days after manufacture, work being commenced on July 16 ultimo, at 5:30 P. M., and was completed on the 17th at 5:15 P. M., that is to say, it lasted about 11 hours. The pile was driven in calcareous rock, up to 48 feet below "zero," and without breaking after receiving 24,450 strokes with a hammer weighing 7,040 pounds.

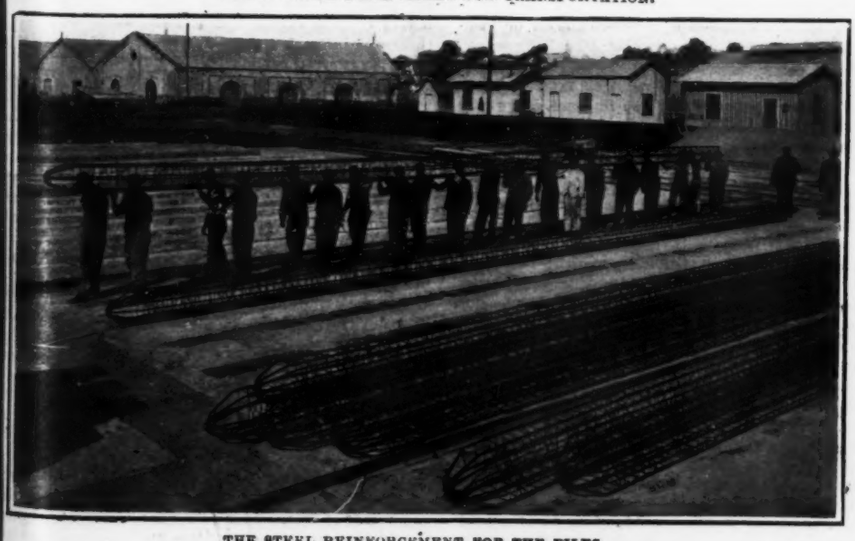
The system apparently has much to commend it from the engineering standpoint, largely because of its economy.



ASSEMBLED AND UNASSEMBLED MEMBERS OF THE REINFORCING SYSTEM.



THE FINISHED PILES READY FOR TRANSPORTATION.



THE STEEL REINFORCEMENT FOR THE PILES.

MIXING THE BATCH.

A NEW SYSTEM OF REINFORCED CONCRETE.

WHAT IS THE ELECTRON THEORY?

A SIMPLE AND LUCID EXPLANATION.

BY PROF. L. GRAETZ.

THE theory that electricity, or electrical charge, is a kind of matter composed of discrete particles, or electrons, has steadily gained ground during the last decade. This theory explains the known facts of statical electricity and many of the phenomena of the electric current. The new theory differs from the old one-fluid and two-fluid theories of electricity in making the electrical substance discontinuous and in recognizing its intimate connection with the all-pervading luminiferous ether.

The discontinuous character of electricity was made evident by Helmholtz's elaboration of Faraday's laws of electrolysis. The two parts into which a compound molecule is divided by the current move in opposite directions, toward the positive and negative electrodes. One of these parts, which are called ions, bears a positive, the other a negative electrical charge. The atoms of all monovalent chemical elements, when thus electrolyzed as ions, carry equal charges, positive or negative. The charge of every divalent, trivalent, or quadrivalent atom is two, three, or four times as large as the charge of a monovalent atom.

This minimal quantity of electricity, the charge of a monovalent ion, is called an electron. On the electronic theory, if the existence of both positive and negative electrons is admitted, an ion may be regarded as an atom combined with positive or negative ions equal in number to the valence of the atom. Thus, as the chlorine atom unites with one hydrogen atom to form a molecule of hydrochloric acid, so it unites with one electron to form a chlorine ion; and as the oxygen atom unites with two hydrogen atoms to form a molecule of water, so it unites with two electrons to form an oxygen ion. Hence, positive and negative electricity may be regarded as monovalent chemical elements, like hydrogen and sodium. In electrolysis the electrons are not set absolutely free, but remain combined with ordinary matter in the unvarying proportions of 96,800 coulombs or 9,680 C. G. S. units of electricity to each gramme-molecule of a monovalent element, double that quantity to each gramme-molecule of a divalent element, and so on. Hence, the specific charge, or charge per gramme, is inversely proportional to the atomic weight, and is greatest for hydrogen, for which it equals 9,680, or approximately 10^4.

Our knowledge of electrons was greatly increased by J. J. Thomson's discovery that cathode rays consist of swiftly-moving particles, negatively electrified. Here, however, the ratio of charge to mass is 1.88×10^7, or about 2,000 times as great as in the hydrogen ion, and as this ratio is independent of the nature of the highly rarefied gas in which the rays are generated, it appears probable that the cathode particles are simply negative electrons, uncombined with ordinary matter. Their maximum velocity is 100,000 kilometers (62,151 miles) per second. The negative electrons which are expelled by radium in the form of β rays have still greater velocities, but a smaller specific charge, or ratio of charge to mass. The mass ascribed to negative electrons is an apparent mass, which increases with the velocity and accounts for the phenomena of inertia exhibited in the movement of the electron through the ether. The positive electron has not been isolated. The positive particles which constitute the canal rays of the exhausted tube and the α rays of radio-active substances are electrified particles of ordinary matter of the magnitude of atoms. Their specific charge (ratio of charge to mass) is equal to or smaller than that of the hydrogen ion (about 10^4).

The intimate connection between electrons and the ether is manifested by the displacements or strains, of two kinds, which are produced in the ether respectively by the presence and by the motion of electrons. The strain is propagated through the ether in all directions with the velocity of light. The ether reacts by exerting mechanical forces on the electrons. On the electronic theory, the attractions and repulsions of electrified bodies, electric currents, and magnets, the induction of currents, and all other electrical effects that are apparently produced at a distance are explained by this interaction of electrons and the ether.

As the electronic theory purports to explain all electrical and magnetic phenomena, including the phenomena of light, it necessarily attributes differences in the electrical, magnetic, and optical properties of substances to differences in the arrangement and motion of the electrons associated with them. Hence, it is assumed that the electrons are attached more or less firmly to the molecules of non-conductors, but are free to move in the interior of conductors. The simplest assumption is that, in metals, the electrons move in the manner of the molecules of gases, communicating energy to each other by their collisions, which occur so frequently that no electron travels through any considerable distance, unless impelled by an electromotive force from without. This is the basis of the electronic theories of metals developed by Riecke, Drude, and Lorentz, but these theories present various points of difference. Lorentz makes the assumption, which agrees best with our present experimental knowledge, that only the negative electrons possess this free mobility, while the positive electrons are more or less firmly attached to the molecules of the metal. Under the influence of an external electromotive force, the free negative electrons have superposed on their irregular motions (which constitute heat) a general movement of progression in one direction, which constitutes an electric current. The average progressive velocity is proportional to the electromotive force, but is always small in comparison with the oscillatory velocities of electrons and molecules.

If the temperature of the metal is not uniform, energy is conveyed from hotter to colder parts by the movements and collisions of the electrons. One of the most striking achievements of the electronic theory is its explanation of the proportionality of thermal to electric conductivity and the proportionality of their ratio to absolute temperature. (Laws of Wiedemann-Franz and Lorentz.) The theory also accounts for the difference of potential between two metals in contact, the thermo-electric currents caused by the temperature variation of this difference of potential, and the so-called Thomson effect, or the evolution and absorption of heat in different parts of an unequally heated conductor. On the other hand, the Hall effect and other thermo-magnetic and galvano-magnetic phenomena exhibited by certain metals, especially bismuth, cannot be explained simply by the free mobility of negative electrons.

Lorentz has shown that the changes of velocity caused by collisions of electrons give rise to waves in the ether, so that the colliding electrons become sources of radiation. These radiant electrons give the metal its power of emitting heat and light. By taking account of the absorption involved in the electric conductivity the emissive power of a black body for long waves can be calculated from the theory. The radiation of black bodies has been the subject of exhaustive research, both experimental and theoretical, during the last decade. Planck's formula, which accurately expresses this radiation, is identical with the formula deduced for long waves from Lorentz's theory.

The fundamental properties of conductors, therefore, are explained by the electronic theory in its present form. The variation of conductivity with temperature, the quantitative effect of the material atoms (which have been hitherto ignored) and the degree of freedom of the positive ions still await elucidation. The remarkable experiments of Hagen and Rubens have proved that the material structure of the conductor produces no appreciable effect when the electrons move slowly, but the molecules of the metal must exert some influence when the vibrations are rapid, as the optical properties of metals cannot be explained by the movement of electrons alone.

The simplest conception of a non-conductor or insulator under electrical stress is that of a body whose molecules are polarized, each molecule containing equal positive and negative charges, or electrons, separated from each other by a little distance. The fact that every non-conductor possesses a definite dielectric constant, or specific inductive capacity, is explained by this simple assumption; but in order to account for other electri l and optical phenomena, particularly normal and abnormal chromatic dispersion, it is necessary to assume, in addition, that the polarized molecule, in general, contains a large number of positive and negati e electrons free to execute a series of vibrations, the periods of which determine the peculiarities of dispersion. Many substances apparently develop groups of very rapid vibrations, corresponding to lines in the ultra-violet region, and also groups of very much slower vibrations, which are represented by lines in the ultra-red region. When the numerical values of the periods, or wave lengths, of these widely separated groups are studied in the light of the electronic theory it appears that the ultra-violet waves emanate from particles having a specific charge, or ratio of charge to mass, equal to 1.8×10^7, and consequently from negative electrons, while the ultra-red waves originate in particles of much smaller specific charge and greater mass, which are presumably positive ions. It can be shown, further, that although an atom may contain a great number of positive and negative electrons, a few of the negative electrons, always equal in number to the chemical valence, are attached more loosely than the rest.

Additional insight into the electrical constitution of atoms and molecules is furnished by the study of spectra, and especially by Zeeman's discovery that certain lines, ordinarily single, are converted into doublets or triplets in a magnetic field. This phenomenon may be explained by the action of the field on vibrating electrons, and the particular character of the effect indicates that these electrons are negative. The Zeeman effect is exhibited only by line spectra, never by band spectra. Now, Kayser and Bunge have shown that a line spectrum may be divided into a number of series, each containing lines of wave lengths connected by definite numerical relations. All the lines of a series exhibit the same behavior in the magnetic field. Hence, the Zeeman effect proves that line spectra emanate from negative electrons. These negative electrons are not necessarily free, but may be members of groups containing positive electrons. Anti-cathode or canal rays, which consist of positively electrified particles, give spectra composed of lines which, as Stark has discovered, are displaced in accordance with Doppler's principle by the rapid motion of the particles, which are thus proved to be the sources of radiation. Hence these essentially positive particles must contain negative electrons which produce the line spectra. As the particles have the same specific charge as electrolytic ions they are supposed to be modified atoms, which have become positive through the loss of a few of their probably very numerous negative electrons.

The theory that atoms are made up of electrons has received additional support from the phenomena of radio-activity, in which atoms are apparently disintegrated into their positive and negative components which appear in the forms of α and β rays. A logical consequence of the theory is the possibility of the transmutation of elements, and this has actually been observed in the production of helium from radium and even (by Ramsay) in the production of lithium from copper. The components of the atom that have revealed themselves are of two kinds: negative electrons and ions or particles of far greater and nearly atomic mass which are, on the whole, positively electrified, but yet contain negative electrons, as is proven by the study of line spectra.

Positive electrons, equal in mass and specific charge to the negative electrons, have not yet been isolated. If, as appears probable, they do not exist, two possibilities remain. The atom may be composed of negative electrons and a material nucleus, which appears positively electrified when it is deprived of all or even a few of the negative electrons which are normally attached to it. This is a new version of Franklin's one-fluid theory of electricity. On the other hand, all matter may be composed entirely of negative electrons. The problem of constructing a positive ion out of negative electrons, though difficult, is not hopeless, but before it can be solved our experimental knowledge of the nature of positive ions must be improved.

The magnetic properties of bodies are explained by assuming that the molecules contain electrons revolving in circular orbits, a conception akin to Ampere's theory of molecular currents. In general, the planes of these orbits are distributed irregularly, but they are brought into parallelism by the agency of an external magnetic force. This is the theory of the structure of iron and other paramagnetic substances. In diamagnetic substances it is assumed that the electrons do not revolve except under the influence of a magnetic field. Our knowledge of the magnetic properties of bodies is still very incomplete and this part of the electronic theory has not been fully developed. Very interesting in this connection is Hensler's discovery that strongly magnetic alloys can be made of feebly magnetic metals.

The electronic theory of matter is yet in its infancy. The elucidation of the details of atomic structure will be a task as laborious and probably as remunerative as the explanation of the formation of thousands of complex organic substances out of a few elements. The molecules of which the structure is fully known contain not more than thirty atoms, and more complex bodies, such as albumen, are very imperfectly understood, but even the hydrogen atom must contain about 2,000 negative electrons, if such electrons are the sole structural elements of matter, and in heavier atoms the number of electrons must increase in proportion to the atomic weight.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

ALCOHOL AS FUTURE FUEL.*

THE POWER POSSIBILITIES OF VEGETATION.

THAT there is a possibility of a future fuel supply in the growth of vegetation from the soil is quite evident when an assemblage of all the facts bearing upon the subject is considered. The manufacture of alcohol from vegetation and its use in the internal-combustion engine opens up the way to possibilities as yet undreamed of. The fact that in the manufacture of alcohol all the substances used are those which the plant obtained from the atmosphere and that also all those nitrogenous compounds which were drawn from the soil may be immediately returned as fertilizer, naturally suggests that alcohol is the proper logical vehicle for the transmission of the sun's energy from the plant to the engine. The great progress that has been made in recent years by such men as Luther Burbank in the development of different species of plants to suit any requirements, and the possibility of manufacturing fertilizer by electric power from the nitrogen of the atmosphere, open up possibilities for the growth of vegetation of the proper kind and in sufficient quantities to meet great demands for power and heat.

It is maintained that alcohol can be produced and marketed much cheaper than the prevailing price of 40 cents per gallon, and that it should soon become a very strong competitor of gasoline for power purposes, both in price and quality. From tests made by the U. S. Geological Survey it was shown that under the most favorable conditions that could be obtained, equal amounts of 73-degree gasoline and commercial denatured alcohol by volume were used per unit of power. Considering the fact that the heat value of a gallon of the alcohol is only about six-tenths that of a gallon of gasoline, the tests showed a much higher efficiency for the alcohol. The amount used was eight-tenths of a pint per brake horse-power per hour for both gasoline and alcohol. It is generally conceded that alcohol can be made equally efficient, if not more so, as gasoline, and that the difficulties in the way of its practical use are pretty generally understood and are by no means insurmountable.

Regarding the possibility of raising sufficient quantities of grain or vegetables to meet power requirements, the following data may be of interest:

	Pounds.	Gallons Absolute Alcohol.
1 bushel corn yields.....	16.53	2.5
1 bushel rye yields.....	15.73	2.4
1 bushel white potatoes yields	5.25	0.8
1 bushel sweet potatoes yields	6.95	1.1
1 gallon molasses yields.....	3.00	0.45

Corn and white potatoes seem to be the favorite materials used in this industry. In the United States in 1895 the total acreage of land in corn was ninety-four million with an average yield of 28.8 bushels per acre, and the total production was 27,000 million bushels. If this had all been used for the manufacture of alcohol, we could have made from this source alone a total of 6,750 million gallons, and this would have been sufficient to generate over 20 million horse-power for 10 hours per day for the whole year, or two-thirds of the total power now used in this country. There are in round numbers approximately 2,000 million acres of land in the United States, and it would no doubt be quite safe to estimate the total area available for agricultural purposes at 1,000 million acres at least, or more than ten times the amount in corn in the year 1895.

Potatoes seem to be the material most generally used for the manufacture of alcohol in Germany, the country which at presents leads in this industry; and while the average yield in the United States is only 45 or 50 bushels per acre, they have grown as high as 600 bushels per acre in that country, where a special kind of potato is used—one that has been developed particularly for the purpose of manufacturing alcohol. During the year 1903, England made two million gallons of alcohol for industrial purposes, France eight million and Germany 25 million. It requires about three bushels of potatoes to yield as much alcohol as one bushel of corn, but if it is possible to obtain a yield as high as 600 bushels of potatoes per acre it would require only one-tenth of our tillable soil to produce a yield large enough to supply alcohol for seven times the power now used in the United States.

Of course, there is not much encouragement for the production of alcohol for power purposes as long as the price remains four times that of gasoline. However, attention has recently been called to the possibility of making alcohol from peat and selling it at a price as low as five cents per gallon. It is said that the peat beds in the Great Dismal Swamp of Virginia are capable of yielding 40,000 million gallons of alcohol. This amount would be capable of supplying the United States with power for only about four years; but as lohg as the mineral-fuel supply lasts, alcohol would be used only for certain special purposes, and in small quantities at first, although at five cents per gallon it would be on practically an equal basis with coal at $2 per ton, considering the present efficiency of the average steam-power plant. The peat beds should serve for the manufacture of alcohol for many years, and meanwhile we should learn to produce much cheaper alcohol from vegetation and take steps looking toward the production of some species of plant having a much more luxuriant growth and better adapted for the purpose than those we now have.

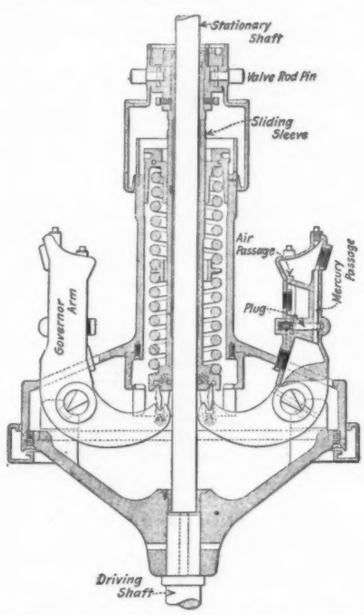
When the manufacture of alcohol from the season's vegetation becomes a large industry in our country, with stills located at convenient points for the delivery of vegetables or grain and the return of the refuse to the soil as fertilizer, we will be completing a cycle which can be maintained season after season and year after year and so on for ages without disturbing or changing in any way the condition of the soil or quality of the air we breathe. All those substances which the plant takes up from the soil are left behind when the alcohol is made, only those substances going into its composition which the plant derived from the atmosphere, these even being returned again to the air in identically the same form when the alcohol is consumed.

* Abstracted from a presidential address by F. W. Ballard, delivered before the Ohio Society of Mechanical, Electrical and Steam Engineers.

THE GLOCKER-WHITE TURBINE GOVERNOR.*

By W. M. WHITE and L. F. MOODY.

THE close regulation of large water turbines is made difficult by the water-hammer action due to the inertia of the water in the penstock. The comparatively sudden action of the ordinary centrifugal governor would produce too rapid changes in the position of the turbine gates, with harmful results proportionate to the head and volume of flow.



SECTIONAL VIEW OF REVOLVING ELEMENT OF TURBINE GOVERNOR.

To bring about a sensitive and yet gradual governing action, a governor with hollow balls containing a shifting charge of mercury has been applied to four 13,000-horse-power and two 500-horse-power water turbines built by the I. P. Morris Company, Philadelphia, for the Electrical Development Company, of Ontario, Canada. The turbines are vertical with double runners discharging into a single draft-tube, and are controlled by cylinder gates. These gates, weighing with the levers and rods which operate them some 15,000 pounds, must be handled by the governor.

A single-acting piston driven by oil at a pressure of 250 pounds per square inch is employed to raise the gates, and the downward or closing movement is effected by the weight of the gates themselves and controlled by the escape of the contained oil from the cylinder. This cylinder is so large, on account of the great weight of the gates which it operates, that its valve is too heavy to be moved directly by the governor balls. A supplementary piston is therefore employed to control the valve of the main cylinder, and the valve of this supplementary or relay cylinder is in turn controlled directly by the governor balls.

The revolving element is shown in the figure. The governor arms, or "balls," moving in or out from the shaft transmit their motion to a sleeve which revolves upon it. A collar at the upper end of the revolving sleeve is provided with two pins which act upon the system of levers controlling the valve of the relay cylinder.

The most novel feature of the governor is the hollow and peculiar shape of the arms. Each arm contains an upper and a lower mercury chamber connected by a small vertical passage. This passage is intercepted by an adjustable plug having a small hole drilled through it at the point where it crosses the passage to allow the transference of mercury from one chamber to the other. The charge of mercury is placed in the lower chamber with the governor at rest. At the normal speed of 500 revolutions per minute the centrifugal action is sufficient to cause the mercury to rise in the passage and divide itself between the two chambers. An air passage is provided in the arms on the side toward the shaft to permit a free flow. If now, for any reason, the speed tends to increase, more mercury will flow to the upper chamber at a rate determined by the size and position of the opening in the plug. If the speed decreases, the mercury will be partially or wholly transferred to the lower chamber.

The governor is so proportioned that if the passage were closed with the mercury in the normal speed position its action would be sluggish, permitting a variation in the speed of 100 revolutions per minute from full load to no load. With the passage open, however, when the load is suddenly decreased and the speed tends to rise, the upward and outward movement of the mercury gradually increases the moment of inertia of the governor arms so that less speed is required to balance the spring. The quickness of recovery from any fluctuation of speed is controlled by the size and adjustment of the opening through the plug and by the shape of the mercury chambers. The shape shown was not worked out mathematically but is the result of several preliminary experiments. This governor is a special design not intended as a competitor of the many excellent commercial governors and has proved very successful.

* Condensed and rearranged by Engineering News from an article in Power and the Engineer.

TACOMA'S EXPERIENCE WITH ITS POWER PLANT.

ACCORDING to a summary published in a recent issue of the Tacoma (Wash.) News, the city purchased a power plant in 1893, which was invoiced at $178,940. The plant consisted of thirteen boilers and fittings, valued at $12,800. There were nine engines, valued at $53,000, and fifteen dynamos and auxiliary apparatus, valued at $120,370.

It appears that there is no record of what it cost the city to manufacture its own electricity. In the comptroller's report for 1898, when the city received its power from the lighting system of the Tacoma Railways Company, it is stated that a saving was effected compared with the operation of the old electric light plant by the city. The Tacoma Railways Company used the same plant, however, which had been operated as a municipal proposition by the city, and which had proved a failure financially. According to the same records, it appears that in 1905 the receipts, in round numbers, were $28,000; operating the plant cost $45,500, and repairs and maintenance cost $6,500, not including the interest on the investment, amounting to another $12,500. In 1906 the operating, repairs, and maintenance cost was $36,000, without the interest, and the receipts were $28,000. In 1907 the figures were respectively $41,000 and $35,000.—Electrical Review and Western Electrician.

What is the difference in rolling mill practice between a continuous and a reversing mill? In a continuous mill the ingots are at approximately a uniform heat, the amount of reduction, and consequently the amount of power required, is governed by fixed passes in the rolls, and it is not a very difficult thing to calculate the power required to drive them. The draft in a reversing mill is not fixed and is all in the hands of the roller; the only thing limiting the tonnage is break-down. The mill is built strong enough to break the engine, and the engine strong enough to break the mill.

UNSINKABLE AND UNCAPSIZABLE SHIPS.*

THE GOULAEFF FORM AND SYSTEM OF CONSTRUCTION.

BY GEN. E. E. GOULAEFF, F.R.S.N.A.

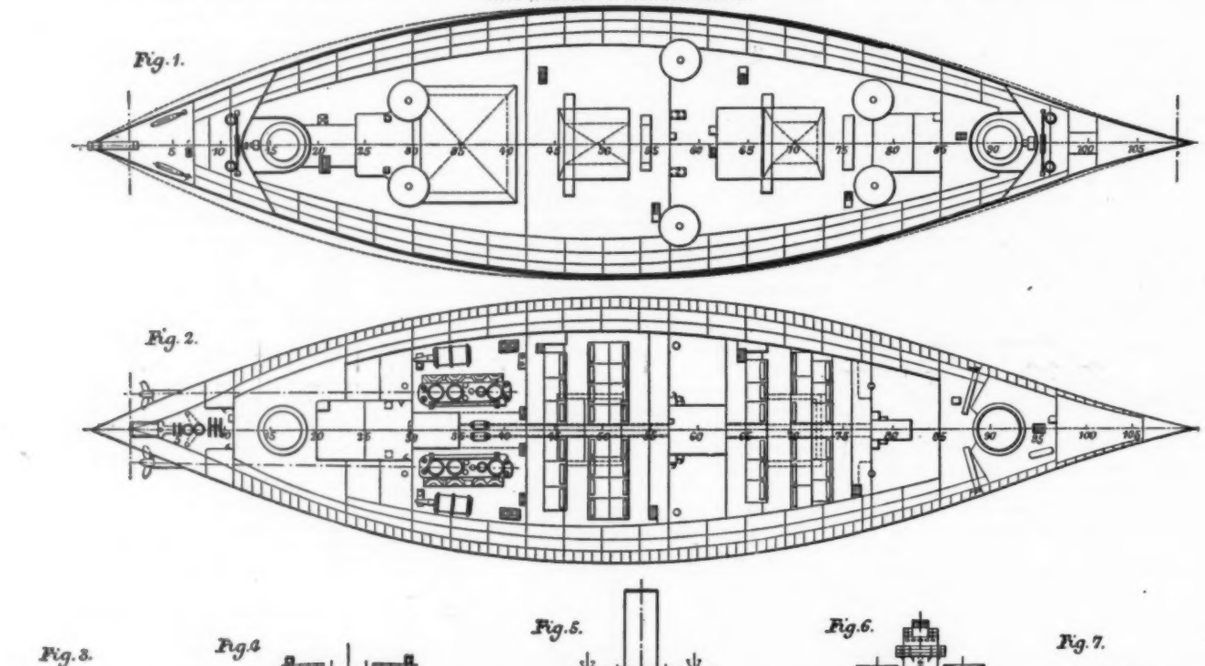
IT is only since the terrible loss of H. M. S. "Victoria" by capsizing (a disaster repeated in several cases during the late Russo-Japanese naval war) that it has at last been recognized that, as soon as a ship of the present ordinary form, proportions, and system of construction receives a blow either by ram, torpedo, shot, or collision, perforating the underwater part of the hull and causing more or less serious injuries, the vessel immediately heels dangerously over and loses her stability. Indeed, owing to the fact that such underwater openings seldom occur exactly in the middle of her length, but mostly at some distance forward or aft, the vessel nearly always rapidly acquires, at the same time, a considerable longitudinal trim, and gets depressed either by the bow or stern, immersing part of her upper structures; that at once jeopardizes her longitudinal stability also, since the useful portion of the area of the load water-line is seriously and very quickly diminished by the inrush of water. By these means the vessel gradually and very rapidly loses whatever stability she might have had originally, and finally upsets or capsizes so rapidly that there are cases recorded in which the actual time of capsizing amounted to less than two minutes. The helpless condition to which many modern warships of various nationalities may be reduced has been actually proved by calculation and model experiments both in Russia and America; while, in the recent war with Japan, some ironclads of the "Borodino" class were seen floating after the battle of Tsushima bottom upward, looking like the backs of some huge species of fish.

Ever since the loss of the "Victoria"—that is, for more than ten years—I have thought how to solve this problem in the most practical manner, and it is the results of my work in this direction that I wish to bring before the Institution of Naval Architects, trusting that the discussion, after the reading of this paper, may prove that the adoption of the proposed form and system of construction will give us practically unsinkable and uncapsizable ships, even in the presence of numerous underwater openings.

Until the present time the most powerful weapon against which we have to specially protect our ships is the torpedo, fired either from torpedo craft or, still worse, from the invisible submarine boats. Moreover, these torpedoes are being continually improved in speed, dirigibility, and weight of bursting charges, and these latter are also being rapidly improved as regards their destructive effect per unit of weight. The external net-defenses, so much thought of formerly, cannot, since the "Belleisle" trials, be considered to effectively answer their purpose any longer, as they were partly burnt and melted by shell fire during these trials. They possess, besides, many disadvantages, as they are cumbersome, difficult, and slow to put in place, and they lessen the speed of the vessel when moving. Being entirely in sight of the enemy, they are liable to be soon destroyed by the fire of comparatively light guns. In the proposed system of construction, comprising, as will be seen from the description, some modification of the form and proportions of vessels, I have endeavored, on the contrary, to protect the ship against this weapon by the internal system of construction of the hull.

I have attained this purpose by making vessels much broader than they have been or are at present, leaving their length the same, or making them even somewhat longer. I shall not trouble the Institution with a detailed description of this form and system of construction, which provides treble broad longitudinal cellular side corridors, which are rendered possible by the increased breadth of the vessel, and are intended to reduce to a minimum the quantity of water that may enter the ship through injuries or openings made in her underwater skin. Fig. 1 gives a general idea of the transverse sections and plans of hold of a ship of this system of construction. The increase of breadth is made at the expense of the draft of water, so much so that the ratio B/D amounts to about 4.5, instead of 2 to 3, as in vessels of ordinary form and proportions. The displacement is practically the same as that of a ship of ordinary form, with which the comparison is made. In the wide treble side there are safety longitudinal corridors, shown in Figs. 1 to 6, surrounding nearly the whole length of the vessel, and I propose to have, as far as practicable, no water-tight or other kind of doors, but only the smallest possible permanently-closed boiler manholes, for the purpose of giving access to the cellular compartments from the top. As members of this Institution will remember, the introduction of the double bottom and double sides, in the early sixties, was due to the remarkable genius of the late Sir Edward Reed, and this innovation was undoubtedly of the greatest importance at that time, when the torpedo had scarcely come into general use. Nowadays, when the conditions of naval warfare have changed so much, and when the injuries that can be produced by a single torpedo are so terrible, some more efficient means must be found to protect ships from this most powerful weapon. The radius of action of the modern torpedo, inside a vessel, counting from the outer skin inward, being about 18 feet, I propose to make the width of the cellular side corridors about 18 feet—that is, 6 feet for each corridor. Thanks to this, all the internal vital parts of the ship, especially those liable to explosion, such as steam boilers, magazines, shot and shell rooms, and torpedo store-rooms, etc., are removed from the outer skin for a distance of about 18 feet inward on each side toward the center of the vessel, thus very efficiently securing their greater safety from any outside explosion, or any other mode of attack. In larger ships I would suggest having this distance increased to about 20 feet.

GENERAL ARRANGEMENT OF AN IRONCLAD OF SOME 17220 TONS DESIGNED ON THE GOULAEFF'S FORM AND SYSTEM OF CONSTRUCTION.



UNSINKABLE AND UNCAPSIZABLE SHIPS.

(I.) *Resistance of Water to the Motion of Vessels of Great Beam.*—When, in 1896-1897, I brought forward my proposal for such ships I was met by the criticism that the resistance of water to the progress of such broad vessels at any high speed would be altogether too great. But, knowing the results of the late Mr. W. Froude's investigations of broad and shallow forms, I felt sure that I was right, at least in this respect.

(a) The diagram in Fig. 8 shows a curve RR of the resistance, or of effective horse-power at different speeds from 13 to 20 knots, of the Russian ironclad "Retvizan," of ordinary form and proportions, compared with a similar curve GG for an ironclad of my own form, and of the same displacement. This diagram, as well as those described below, is based on the results of model experiments made in the St. Petersburg experimental tank, and the curves given in the resistance diagrams are the results of the trials of the models of several ships of the forms stated on the diagrams. Fig. 8 shows that, while the displacement of both vessels is the same (14,266 tons), the indicated horse-power of engines required to drive a

* Paper read before the Institution of Naval Architects.

ship of the "Retvizan" shape at a speed of 18.4 knots amounts to 23,600, while the indicated horse-power required to drive a ship of the broader and shallower form at practically the same speed—18.42 knots—amounts only to 19,412, and this difference in favor of the broader vessel increases if the speed be further increased.

(*b*) Fig. 9 shows a comparison of a later and better-shaped Russian ironclad, the "Borodino," still of an ordinary form, with an ironclad of my form and proportions, both brought, as in the first case, to the same displacement—17,220 tons. In this case we notice that the point of intersection of both curves occurs at an ordinate corresponding to a little higher speed—viz., 18.5 knots (instead of 17.5 knots, as in Fig. 8). In this case the indicated horse-power required to drive the ship of ordinary ("Borodino") shape at a speed of 19.65 knots amounts to 30,400, while the indicated horse-power required to drive the broader and shallower ship, even at a little higher speed—20 knots—amounts only to 26,920.

(*c*) Fig. 10 shows the comparison of the curves of effective horse-power for a very fast protected Russian cruiser, "Askold," of ordinary form, and the curve *G G G* for an armored cruiser of the same displacement (13,180 tons), of my own form, specially designed for high speeds. In this case the superiority of the proposed ship is still very striking, as shown by the fact that the point of intersection of these last two curves occurs at as low a speed as about 10 knots. Beyond this limiting speed, and up to 25 knots and over, the curve *G G G* keeps below the curve *A A A*, which latter, as in the case of the two previous diagrams referred to, has an almost asymptotic character the higher the speed grows.

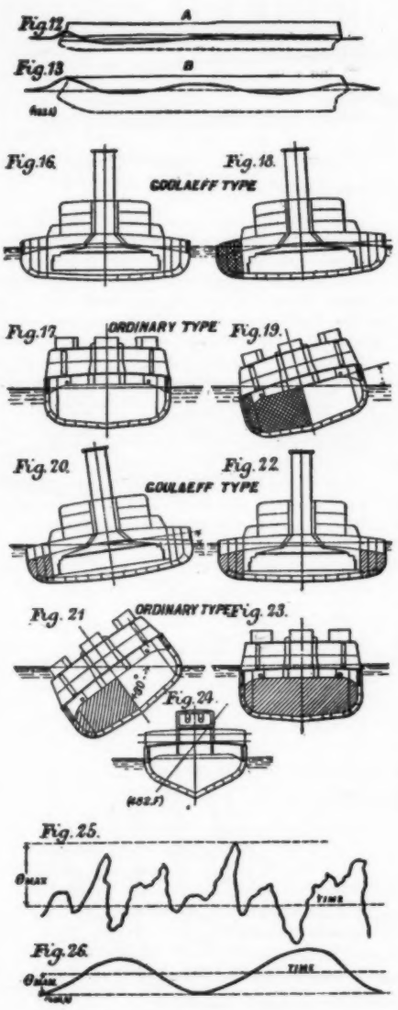
(*d*) Fig. 11 shows the curves *C* and *D* of the effective horse-power of a large ocean steamer of my form and proportions at her two different drafts of water—viz., 18.33 feet and 20.33 feet—of a normal displacement of 23,000 tons (steamship "Deutschland's" displacement), among a group of similar curves of effective horse-power belonging to different steamers of ordinary form—viz., Curve *A*, "Grozyaschy"; *B*, "Sveltana"; *E*, "Good Hope"; *F*, "Merkara"; and *G*, "Kaiser Wilhelm der Grosse"—all brought to the same displacement of 23,000 tons. It is interesting to note, *en passant*, that the small difference between the ordinates of the curves *C* and *D* shows that even considerable overloading (about 2,700 tons) of a vessel of my form will not affect her high speed very materially, which is no small advantage for a merchant steamer, especially as the displacement per inch immersion in the vessel of this form and proportions is almost double that of a vessel of ordinary narrow form. In this case the difference of indicated horse-power required to drive these vessels at the same speed of 25 knots amounts to from 20,000 to 24,000 indicated horse-power in favor of a vessel of the broader and shallower form, which is very important, as showing again that the higher the speed at which we make our comparison the more advantageous becomes my form of ship, in respect of the resistance of water. This favorable result is, no doubt, obtained owing to the considerable reduction in the draft of water, and, consequently, of the pressure of water against which the ship has to labor in her progress, the vessel, so to speak, skimming over the water's surface.* The superiority is so great that, as shown by this diagram, a steamer of my form would be capable of developing nearly 27 knots, as compared to 25 knots for a steamer of ordinary form, of the same displacement, and with the same power of engines.†

Figs. 12 and 13 on this page show the difference of the wave formation accompanying the motion of a vessel of my form *A*, and that of a ship of ordinary form *B*, when both are driven at the same speed—about 20 knots. The wave formation in the first case is remarkably less than in the second, and this absence of wave-making clearly explains the facts already mentioned in favor of the proposed form of ship, since it is especially with an increase of speed that the wave-making resistance of ships of the ordinary form grows enormously.

The final results of these investigations of ship resistance prove that with the ordinary form of ships we have nearly reached the limit of advantageous increase of speed, beyond which, however much we increase the propelling power of machinery, we get scarcely any adequate increase of speed. Practically this has been proved for several years past by the enormous sacrifices which naval architects have to make in order to obtain the last few additional knots out of a ship of the usual form. The proposed type of ship would, moreover, admit of placing on board, thanks to its great beam, any required number of turbine-driven propeller shafts.

(II.) *Insurance of such Vessels against Sinking and Capsizing.*—Ships of my proposed system of construction possess, as compared with ordinary ones, incomparably greater "unsinkability" and "uncapsizability" under the effects of torpedoes, shot, rams, and collisions with other ships. The following table will illustrate this point.

From the table it is evident how much more moderate an angle of heel a ship of my form takes as a result of underwater injuries to the hull, compared with an ordinary ship of the same size, under exactly the same conditions. At the last angle of heel given in the table (30 deg.) of the ironclad of ordinary



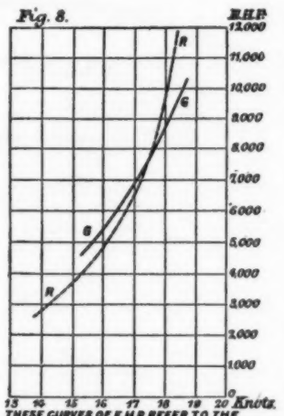


Fig. 8.
E.H.P.
THESE CURVES OF E.H.P. REFER TO THE DISPLACEMENT OF 14266 TONS OF THE IRONCLADS.
G.G. OF THE GOULAEFF TYPE AND R.R. OF H.I.M. IRONCLAD "RETVIZAN" OF AN ORDINARY FORM.

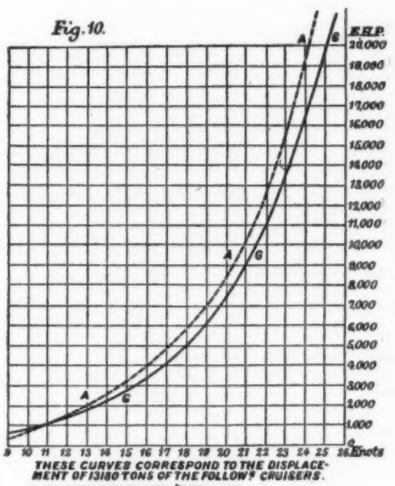


Fig. 10.
E.H.P.
THESE CURVES CORRESPOND TO THE DISPLACEMENT OF 13180 TONS OF THE FOLLOWING CRUISERS.
A.A.A. TO AN ORDINARY "ASKOLD"
G.G.G. TO A CRUISER OF THE GOULAEFF TYPE.

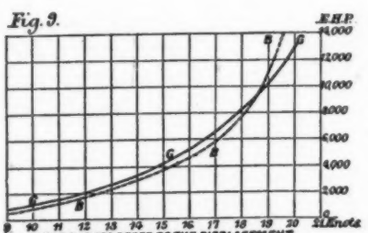


Fig. 9.
E.H.P.
THESE CURVES REFER TO THE DISPLACEMENT OF 17220 TONS OF THE IRONCLADS.
B.B. OF THE ORDINARY H.I.M. "BORODINO"
G.G. OF THE GOULAEFF TYPE.

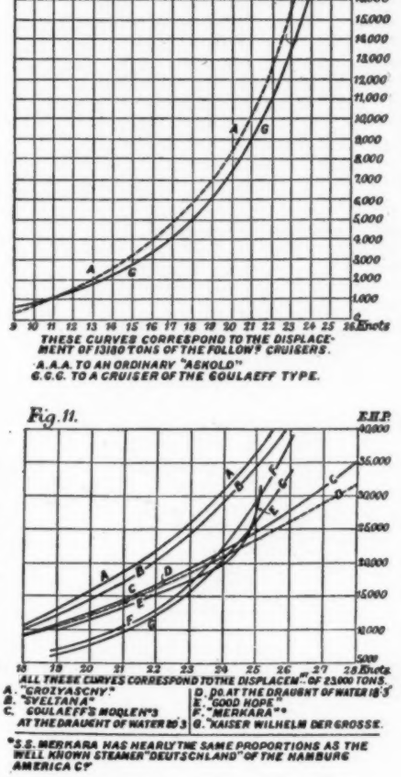
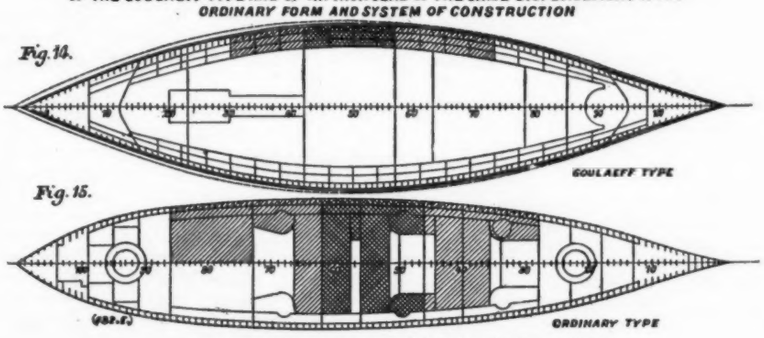


Fig. 11.
E.H.P.
ALL THESE CURVES CORRESPOND TO THE DISPLACEMENT OF 23,000 TONS.
A. "GROZYASCHY"
B. "SVELTANA"
C. GOULAEFF'S MODEL No 3 AT THE DRAUGHT OF WATER 20' 3"
D. DO. AT THE DRAUGHT OF WATER 18' 3"
E. "GOOD HOPE"
F. "MERKARA"*
G. "KAISER WILHELM DER GROSSE.
*S.S. MERKARA HAS NEARLY THE SAME PROPORTIONS AS THE WELL KNOWN STEAMER "DEUTSCHLAND" OF THE HAMBURG AMERICA C°

RESULTS OF THE CALCULATIONS OF THE COMPARATIVE ANGLES OF HEEL OF AN IRONCLAD OF THE GOULAEFF TYPE AND OF AN IRONCLAD OF THE SAME DISPLACEMENT OF AN ORDINARY FORM AND SYSTEM OF CONSTRUCTION



UNSINKABLE AND UNCAPSIZABLE SHIPS.

* This same reason, no doubt, accounts also for the excellent results of Mr. Yarrow's motor torpedo boat having a ratio of $\frac{B}{D} = 9$ (that is even greater than in the ships of my proposed form and proportions), and also a flat bottom.

† All the curves of effective horse-power in Fig. 11 were drawn by the staff and on the authority of the St. Petersburg Experimental Tank, and were obtained mostly as the results of trials of models of the ships referred to in the diagram, with only three exceptions—viz., of the curve *F* for the steamship "Merkara," the data for which were taken from the corresponding diagrams given by the late Mr. William Froude in the Transactions of the Institution of Naval Architects; of the curve *E* for the cruiser "Good Hope," the data for which were drawn from the figures given in the published accounts of this vessel's measured mile trials; and of the curve *G* for the German steamship "Kaiser Wilhelm de Grosse," the data for which were taken from the Transactions of the German Institution of Naval Architects.

form, her side turrets enter the water, and the vessel herself becomes immersed to a draft of 33.25 feet by the bow and 36.12 feet by stern, with a still further increase in the quantity of water inside of her, pouring in through the above-water ports and through possible openings made by artillery fire in her sides, and spreading along the interior of the 'tween decks, causing her to lose more and more of her stability,

TABLE I.

—	Displacement, 17,220 tons.	
	Ironclad of the Goulaeff form and system of construction.	H.I.M. Ironclad Emperor Paul I., of ordinary form and system of construction.
	deg. min.	deg.
Angles of heel under the same conditions of underwater injuries made by torpedoes. Extent of injuries lengthwise, 60 ft.	2 40	14
Angles of heel under the same but still more extensive and severe underwater injuries made by torpedoes. Extent of injuries lengthwise, 170 ft.	6 50	30

until she finally capsizes; whereas, under the same conditions, as shown in Figs. 15 and 16, an ironclad of my form after being struck even by several torpedoes still remains perfectly able to fight her guns or to proceed under her own steam to her destination. The comparative smallness of her angle of heel is shown in Figs. 16 to 24, representing the results of extensive calculations of the stability of both vessels, with some compartments (those shaded by the drawing) filled with water, the extent of the underwater

Fig. 27. DIAGRAM OF AMPLITUDES OF ROLLING.

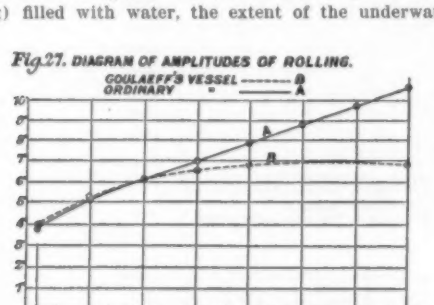
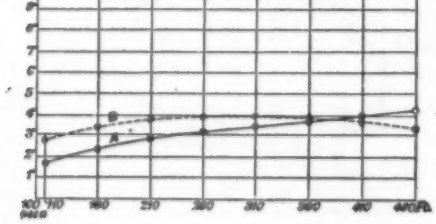


Fig. 28. DIAGRAM OF ANGULAR VELOCITIES OF ROLLING IN DEGREES PER SECOND.



injuries sustained being taken lengthwise at 60 feet and 170 feet, with a radius of destruction of the torpedo 18 feet inward.

The adoption of this system of construction in mercantile steamers would, therefore, enormously increase their safety in case of collision, and would, consequently, reduce the rates of insurance required by underwriters.

(III.) *Reduced Draft of Water (amounting in big battleships to some 6 feet or 7 feet, and an even greater reduction in large mercantile steamers).*—In ships of ordinary form the limit of draft available has already been practically attained by the limiting depth of water in certain important channels and ports, unless we resort to a vast amount of artificial dredging. This would take time, and would, moreover, be too costly. Rather let us adapt our ships to that depth of water which is given us gratis by nature. My form and system of construction would not only satisfy this condition, but would greatly reduce the number of cases of ships grounding on shallows or rocks, thus offering additional security for navigation in shallow seas and intricate channels.

(IV.) *Increased Internal Capacity.* — Increased breadth insures so much additional internal capacity that great quantities of fuel or other cargo may be stowed on board such ships as compared with ships of ordinary narrow form, and this favors the adoption of such ships either for distant cruising purposes or for carrying a large cargo in hold, and passengers above in the central upper structure. In a tentative design of an ocean steamer of high speed, of my form, thanks to the height to which her central superstructure could be raised, most of the passengers—numerous though they were—could have been each accommodated with an excellent and spacious stateroom, and the natural lighting and ventilation much improved besides.

(V.) *Safety against Explosion of the Ship's own Magazines and Torpedo Store Room.*—The safety cellular corridors so effectively isolate all the vital parts and stores of the ship liable to explosion and ignition, such as magazines, torpedo store-room, etc., from the outer skin of the vessel, that the blowing up of these by detonation from the explosion of an enemy's torpedo or mine outside in the vicinity of these parts is most efficiently prevented—just such an explosion as caused the foundering and capsizing in the late war of H. I. M. S. "Petropavlovsk," with the gallant Admiral Makaroff, and nearly all his officers and crew.

So far, I have only described and discussed the positive or superior qualities of the vessels of the proposed form and system of construction, restricting myself to their main features and properties. I will now discuss those few features which have raised doubts in some quarters. These are:

Fig. 29.

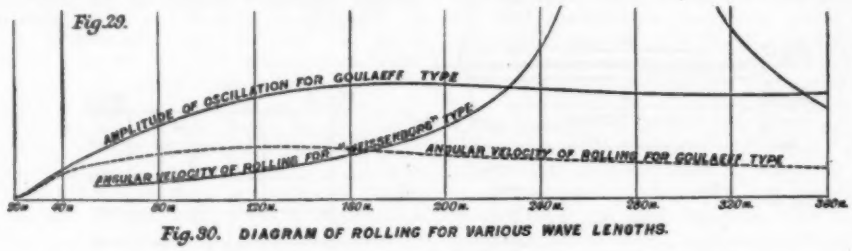

AMPLITUDE OF OSCILLATION FOR GOULAEFF TYPE
ANGULAR VELOCITY OF ROLLING FOR "WEISSENBURG" TYPE
ANGULAR VELOCITY OF ROLLING FOR GOULAEFF TYPE

Fig. 30. DIAGRAM OF ROLLING FOR VARIOUS WAVE LENGTHS.

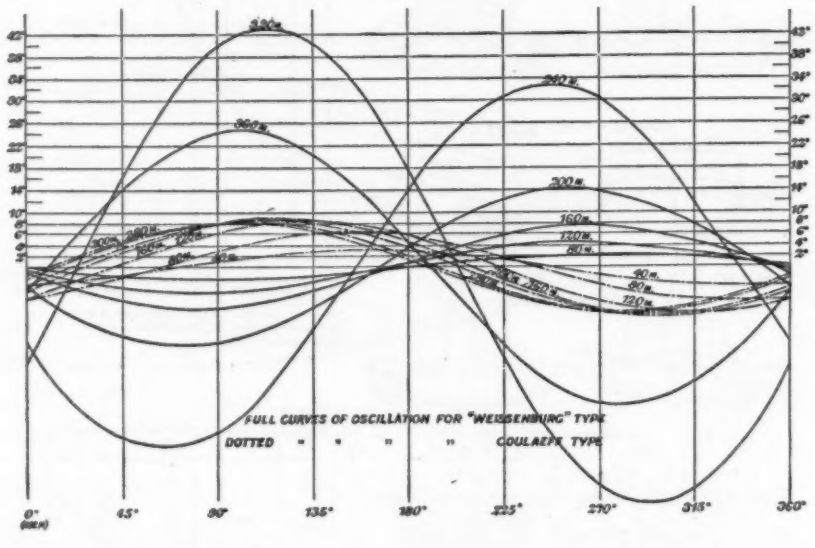


Fig. 31.

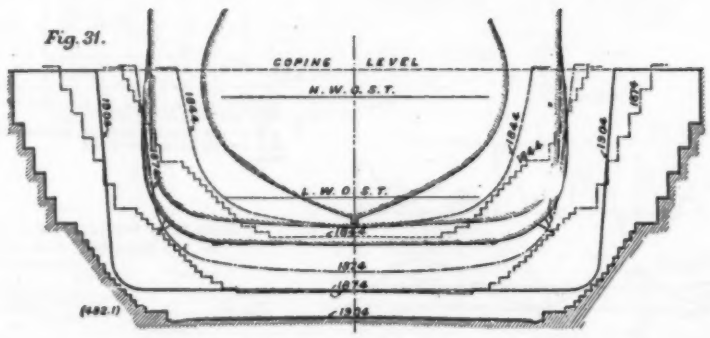
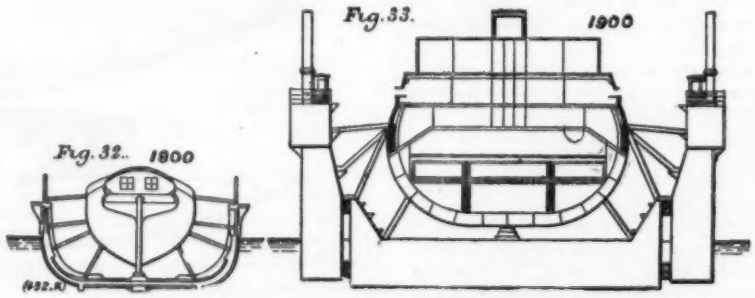


Fig. 32. 1800

Fig. 33. 1900



UNSINKABLE AND UNCAPSIZABLE SHIPS.

(VI.) *Sea-going Qualities of these Ships and their Steadiness of Platform.*—It has been urged that, owing to the increased breadth of such ships, their stability, measured by the metacentric height, being increased, they should be less steady in a seaway than narrower and less stable ships of the ordinary deep form. This, of course, has been taught in the elementary text-books, in which our generation studied naval architecture, but there are new theories which have at last thrown more light upon this complex question of the rolling of ships upon waves of particular size and character. Having studied this question in connection with the rolling of ships of my form, I will now submit the following interesting facts and data:

(*a*) Mr. Ivan G. Boobnoff, of the I. R. N., a member of this Institution, has described the probable rolling of the vessels of my form in the following words:

"These broad ships, possessing as they do a very large co-efficient of extinction, will have transverse rolling more similar to the longitudinal of ordinarily shaped ships—that is, a uniform one, without stoppages, and of the same period as the period of the waves. These ships' own oscillations will be reduced by their great breadth, as well as by other peculiarities of their form, so that the ship will roll uniformly, though rather briskly, but with small amplitudes."

Basing his calculations on Mr. R. E. Froude's formula, given in his valuable paper on "Non-uniform Rolling," Mr. Boobnoff has calculated the figures given in the following Table II. of comparison of the amplitude and angular velocities of the rolling of two typical ships—viz., of H. M. S. "Revenge," of the ordinary form, and of an ironclad of the broad and shallow form.

The general character of the rolling of both vessels compared is shown in Mr. Boobnoff's diagram in Figs. 25 and 26, from which we can judge of the superiority of the rolling of a vessel of my form and type in comparison with the rolling of a ship of ordinary form, both in respect of the regularity or uniformity of rolling motion, and of the comparative smallness of the amplitudes of oscillation. Indeed, judging by this diagram and Table II., and seeing that the oscillations of my ship are so remarkably regular and uniform and become less and easier the bigger grow the waves (second half of the Table II.), we may expect that the accuracy of pointing and firing guns mounted on board such vessels will be very much better attained than that of the guns mounted on board a vessel of ordinary description, and this is a very great advantage for ships of war. From Table II. we also see that,

although the rolling of the broad ship is not so moderate in amplitude of oscillation, and not so gentle in angular velocity, when rolling among small waves of a length from 82 feet to 513 feet long and of a period of 4 to 10 seconds, there is undoubted superiority and a very essential reduction of rolling as soon as she finds herself among waves of 738 feet to 1,660 feet and over, and having a period of 12 to 18 seconds and upward.

TABLE II

Period of the waves in seconds	4	6	8	10	12	14	16	18
Length of the waves in feet	82	185	328	513	738	1000	1300	1660
Amplitudes;—	deg. min.	deg. min.	deg. min.	deg. min.	deg. min.	deg. min.	deg. min.	deg. min.
Maximum for H.M.S. Revenge	1 3	3 2	6 0	10 8	16 3	22 5	28 0	23 0
Maximum for Goulaeff's ship	2 1	6 0	9 0	10 0	10 0	10 0	10 0	10 0
Angular velocities of oscillation, degrees per second:—								
Maximum for H.M.S. Revenge	0 5	1 3	2 4	4 3	6 5	9 0	11 2	9 3
Maximum for Goulaeff's ship	3 0	6 0	7 1	6 3	5 2	4 5	4 0	3 5

N.B.—In this Table the maximum wave-slope was taken by Mr. Boobnoff in all cases as equal to 10 deg., and the mean period of the waves in closed seas as not exceeding 10 seconds.

TABLE III.

Length of waves in metres .	20	40	80	120	160	200	240	280	320	360
Length of waves in feet	66	133	263	394	526	657	789	920	1052	1183
Period of waves in seconds ..	3.58	5.06	7.15	8.8	10.12	11 3	12.4	13.4	14.3	15.18
Amplitude of oscillation to port and starboard:—	deg.	deg. min.	deg. min.	deg. min.	deg. min.	deg. min.	deg. min.	deg. min.	deg. min.	deg.
Maximum for Weissenburg type	...	..	2 20	4 50	7 40	23 0	..	43 0	..	25
Maximum for Goulaeff type ..	0.05	2 20	5 40	8 0	9 0	8 50	8 27	8 10	8 05	8
Angular velocity of rolling:—										
Maximum for Weissenburg type	..	..	0.0353	0.0598	0.0834	0.1388	0.2918	..	0.329	0.1732
Maximum for Goulaeff type ..	0.0025	0.0512	0.087	0.0995	0.0974	0.0805	0.0734	0.067	0.0621	0.0555

(*b*) Figs. 27 and 28 were calculated and drawn up by Col. A. N. Kriloff, I.R.N., chief of the St. Petersburg Experimental Tank. While the diagram given above represents only the general and approximate or qualitative illustration of the character of the probable rolling of my ship, the diagrams in Figs. 27 and 28 show a closer numerical or quantitative comparison of the rolling of the two ships, when both are moving at the same angle (45 deg.) to the direction of the waves, the abscissæ representing the lengths of waves in feet, and the ordinates on the upper figure representing the amplitude of rolling in degrees, and those on the lower figure the angular velocities of rolling in degrees per second. Here again we notice the intersection of the curves in the upper and lower figures (indicating a complete change of phenomenon), and that, although for shorter waves the rolling of a ship of ordinary form is more moderate both in respect of amplitude and angular velocity, this superiority stops at the point of intersection of the curves, after reaching which, and as the waves increase in length and period, the rolling of the ship of my form becomes less than that of the ordinary ship, both in respect of the amplitude and in respect of angular velocity of oscillation.

(*c*) This peculiarity has been most kindly explained to me by Mr. R. E. Froude in a letter on the subject in the following terms: "I agree with what I take to be your views also—namely, that, starting with a design of ordinary type, with small metacentric height, a moderate increase of metacentric height tends to increase extreme angle of rolling and to increase prevalence of rolling (that is, to widen the range of conditions under which rolling takes place); but that an extreme increase, such as you propose, will tend, perhaps considerably, to diminish the extreme angles of rolling and give a ship freer from severe angles of rolling than one of ordinary type (unless the latter is fitted with very large bilge-keels). . . . There is something to be said on both sides, and the question really depends on a balance of evils."

(*d*) Mr. Tekhel, a learned naval architect, has sent me the diagrams shown in Figs. 29 and 30, with Table III. corresponding thereto, confirming the reduction of rolling in the vessel of my form and type, as compared with that of a ship of ordinary form, as the waves increase in length and period. He claims special accuracy for his calculations, particularly in relation to the smaller waves. From his diagram, as well as from Table III., it will be seen that, when rolling among waves having a length of 1,052 feet and a period of 14.3 seconds, a ship of my form attains an amplitude of oscillation of only 8 deg., while a ship of ordinary form of the German H. I. M. S. "Weissenburg" class, for instance, rolls in an amplitude of about 43 deg., the corresponding angular velocities of oscillation being in the proportion of 0.062 to 0.329 respectively—that is, about five times as slow in favor of the ship of my form. In the preceding column of Table III., relating to waves of 920 feet and 13.4 seconds period, no amplitude or angular velocity of the "Weissenburg's" rolling is given, because in this case the period of the vessel herself synchronizes with the period of the wave, and her rolling is therefore still worse, while my ship continues to oscillate with the same uniformity of amplitude (i. e., about 8 deg.), with a moderate angular velocity of 3.84 deg. per second, which latter figure is obtained by multiplying the figure given in Table III. by $\frac{360 \text{ deg.}}{2\pi}$. Another important feature arising out of this diagram and table is that, while the amplitudes of oscillation of an ordinarily shaped ship are subject to such great variation, with the variation in the size of waves, as from 2 deg. to 43 deg., there is scarcely any variation at all in the amplitudes of oscillation of the ship of my form. As to the somewhat increased velocity when rolling among very small waves, my opinion, shared, I believe, by all practical men, is, that when we come to deal with big ships, especially those moving at high speed, small, short waves have much less effect the bigger the ship, and of whatever form she may be.

(*e*) Mr. C. Tennyson, M.I.N.A., studying the same subject maintains that "a ship of my form, following in her motion that of the waves, will be always remarkably dry, floating like a duck, whatever may be the condition of the waves about her, and therefore she will never be swamped, as this is prevented by the closing of all her above-water hatches, side-lights, ports, and other openings; persons on board of her will feel as though the ship does not roll at all; and the work on board will not be impeded by rolling."

(*f*) That such will be the actual sea-going qualities of ships of the proposed form, notwithstanding their large metacentric height, is fully confirmed by practical experience, as proved by the evidence and opinions of the following high authorities, who expressed themselves on this subject, in this very Institution, at the discussion which followed the reading of the late Sir Edward Reed's paper, in the year 1881, on the behavior of the yacht "Livadia" in the Bay of Biscay—viz.: the late Vice-Admiral Sir Houston Stewart, Sir William White, Vice-Admiral Selwyn, and the late Sir William Pearce.*

In view of the extremely favorable opinions of such authorities in regard to the excellent behavior of the "Livadia," only 235 feet long, 150 feet beam, drawing only 7 feet to 8 feet, and therefore possessing, owing to her unprecedented beam, a very great metacentric height, I believe that the application of this form and system of construction to the modern ocean passenger steamers ought to be eminently successful, both as regards high speed on the passage, and also for comfort and safety which passengers would enjoy on board such steamers.

(VII.) In Sir Edward Reed's paper on the "Livadia" in the Bay of Biscay, he pointed out that "a ship of extremely light draft and of almost perfect steadiness receives violent upward blows from the ascending water, and this more especially forward, where the onward motion of the ship naturally subjects the bow to the additional violence. This certainly was the case with the 'Livadia' during the gale we then experienced in the Bay." To this I must answer that ships of the proposed form and proportions differ so very much from the "Livadia" in that they certainly draw not less than 20 feet to 21 feet, instead of, as in the "Livadia," only 7 feet to 8 feet, and in being of much larger displacement, greater length, and finer entrance, so that they would behave in this respect more like ordinary steamers in ballast, whose draft of water happens to be at times even less, and which still make very good passages across the North Atlantic, even in the severe winter seasons.†

(VIII.) *Dock Accommodation Difficulty.*—Seeing that ships of the proposed type and of large displacement, such as that of modern battleships and ocean steamers of ordinary form, would certainly be as much and even more than 100 feet in breadth, objection has been raised as to the difficulty of finding docks wide enough to accommodate such broad ships for the purpose of underwater repair and painting. At first sight this may seem to be a serious disadvantage, but it does not present an insurmountable obstacle, for the necessity for broader docks was keenly felt as long ago as the seventies of the last century, when in the well-known "Inflexible" Committee's report it was stated: "We note that the beam of the 'Inflexible' was limited by the consideration of the docks available for her repair, but we doubt if this consideration ought to outweigh the great advantages which a further increase of beam would give to vessels of the 'Inflexible' type. We are the more inclined to doubt it, because at present docks capable of accommodating vessels of any breadth can be constructed of iron rapidly, and at no serious cost in comparison with that of such vessels as the 'Inflexible.'"

Indeed, floating docks now offer a most ready and suitable way out of this difficulty, and their cost is so moderate that there was lately an offer from a well-known shipbuilding firm to build for England an ironclad of my form, together with a floating dock to accommodate this ship, for exactly the same price as an ironclad of the same size but of ordinary form being built in a Russian yard. The "Dewey" floating dock, built by the American government for their new naval station at Cavite, has an internal width of 100 feet in the clear, and floating docks of still greater breadth might easily be built.

As for the masonry graving docks, even for modern ships of ordinary narrow form and proportions, we already meet with the difficulty of accommodating ships fitted with bilge-keels of sufficient size to diminish their rolling, on account of the narrow entrances to the existing dry graving docks. Indeed, if we consider the growth in the internal dimensions of even such drydocks, we see that, owing to the constant and uninterrupted increase in the size of ships generally, and particularly in their breadth, for the last ninety years, at intervals of thirty years—viz., 1844, 1874, and 1904—we find an increase of width of docks, such as shown in Fig. 31.* The next diagram (Figs. 32 and 33) shows similarly the evolution in the dimensions of a floating dock during the period of last century—from 1800 to 1900. The internal width has almost doubled, thus proving the truth of the saying that where there is a demand there will be always a supply. The width of the new No. 5 graving dock at Cherbourg is already 118 feet; that of the new Brooklyn dock, 120 feet.

With regard to the width of important navigable channels, it may be added that it is proposed to nearly double the width of the Northern Ship Canal at Kiel, while the width of the Suez Canal may be estimated by the fact of its allowing the big American floating dock, having a total breadth of some 125 feet, to be recently towed through it safely.

* Transactions of the Institution of Naval Architects, 1881, vol. xxii., pages 271–280.

† See Mr. Thearle's paper in the Transactions of the Institution of Naval Architects, 1905, vol. xlv., page 118.

THE TRANSVERSE STRENGTH OF CONCRETE.

As a preliminary to a comprehensive research into the properties of ferro-concrete, the United States Geological Survey have recently completed a series of tests on the transverse strength of concrete beams. The results, as was anticipated, showed that concrete was unreliable when subjected to tensile stresses, since not only is its tensile strength low, but when it does fail under tension it does so suddenly and without warning, while reinforced concrete usually shows a development of cracks long before the fracture. The beams used in the experiment were made with a cement having, when tested neat, a tensile strength of 709 pounds at seven days, and of 840 pounds at the end of a year. The aggregates were granite, gravel, limestone, and cinders, and the mixture was in all cases intended to be in the proportions of 1 of cement to 2 of sand and 4 of aggregate. In actual fact, however, the cinder mixture was made more nearly in the proportions 1 : 2 : 5 than 1 : 2 : 4. In general, mixtures mixed very wet proved less strong than drier ones, but the discrepancy lessened with age. The experiments showed throughout a fair parallelism between the transverse strength and the crushing strength of the concrete. The cinder concrete had a crushing strength in 6-inch cubes of about 1,250 pounds per square inch at the end of four weeks, which increased to about 1,800 pounds at the end of thirteen weeks. At corresponding dates the transverse test of beams 8 inches by 11 inches in section, and 12 feet between centers, gave a modulus of rupture of about 180 pounds and 230 pounds respectively. This modulus of rupture is, of course, the bending moment divided by the product of the breadth and the square of the depth. The concrete made with the granite aggregate was much the strongest of the series, but the short-period tests showed that the greater or lesser quantity of water used in mixing greatly affected the strength. Mixed very wet, 6-inch cubes four weeks old broke under a load of 3,200 pounds per square inch, while mixed "dry" the strength at the same age ran up to 4,500 pounds per square inch. At an age of twenty-six weeks the corresponding figures were 4,600 pounds and 5,400 pounds respectively. The modulus of rupture for wet mixtures of this aggregate was 375 pounds at four weeks, and 500 pounds at twenty-six weeks; while mixed "dry" the figures were 500 pounds at four weeks and 590 pounds at thirteen weeks. In spite of the rapidity with which "dry" mixtures attain

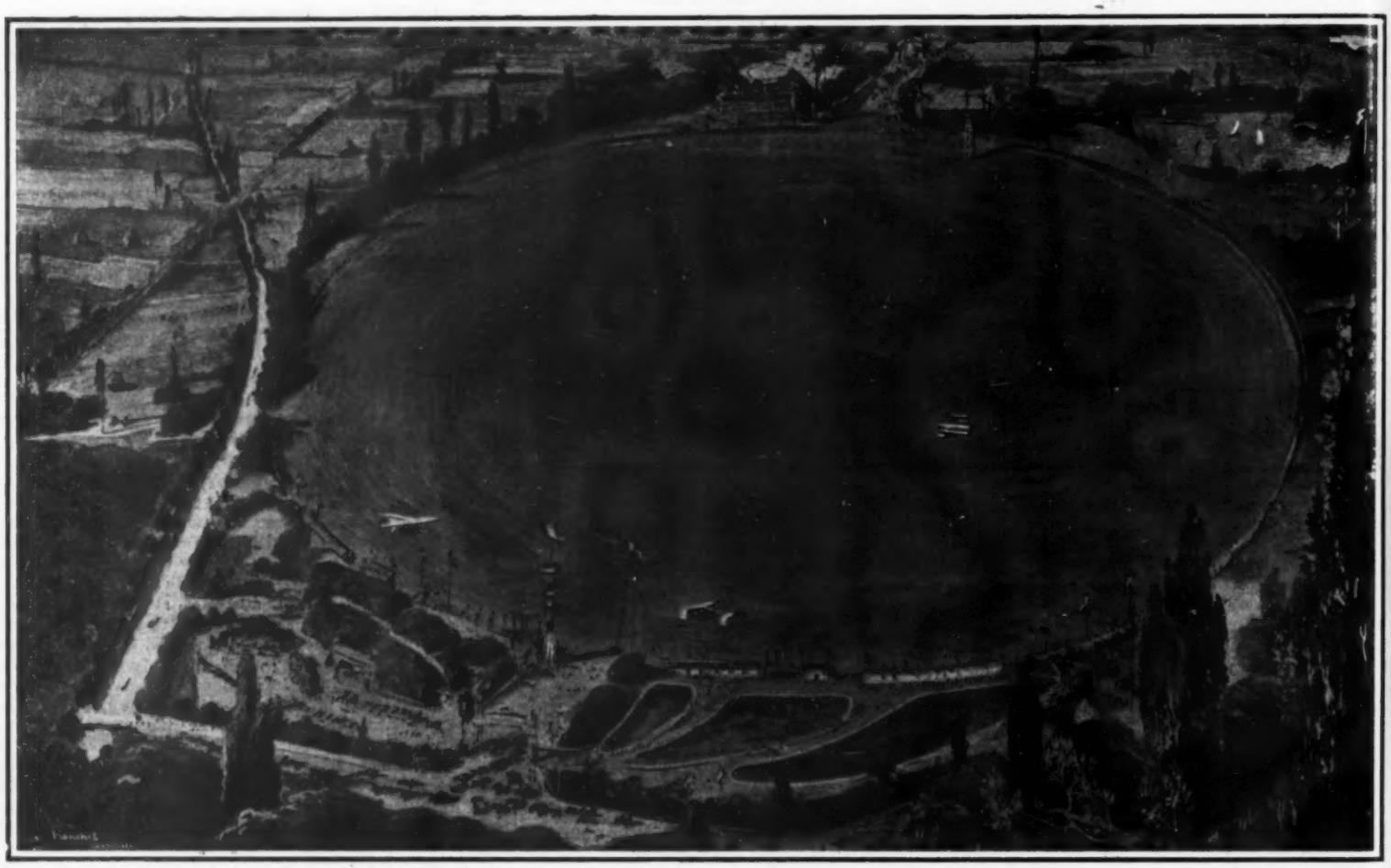
† From Engineering, September 30, 1904, vol. lxxviii., page 450.

strength, it is pointed out in the report that they are unsuitable for ferro-concrete, as in practical work not only would there be a danger of "drying out" the concrete while hardening, but wet mixtures give a more intimate union with the steel. The elastic modulus of the different concretes was also determined. The results obtained with the cinder concrete were discordant, but more consistent results were obtained in the case of the other aggregates. In general, with these the modulus was found to vary with the age of the concrete, but there was no very serious difference between the results obtained at the end of thirteen and twenty-six weeks. In the case of the granite, gravel, and cinder concretes the modulus was higher at the end of thirteen weeks than after the lapse of half a year. Up to a load in compression of 2,000 pounds per square inch the modulus in the case of the limestone and granite aggregates was about 4,000,000 pounds per square inch, and was higher, or about 4,800,000 pounds per square inch, for the gravel concrete. As stated, the values obtained with the cinder concrete were irregular, but at twenty-six weeks old the modulus up to loads of about 1,000 pounds per square inch was about 2,000,000 pounds.

THE FIRST AERODROME IN THE WORLD.

A RACECOURSE FOR ARMY FLYING MACHINES.

ABOUT twelve miles from Paris, in the center of a large plain, the French Society for the Encouragement of Aviation has established a trial ground and racecourse for aeroplanes and other airships. This aerodrome, the first of its kind, has been named Port Aviation. It is slightly larger than the racecourse at Longchamp, and contains an oval track about two miles long and stands accommodating 7,000 spectators, besides shelters for aeroplanes and dirigible balloons, repair shop, restaurant, post office, telegraph station, meteorological observatory, etc. The decorations are suggestive of flight. At the backs of the stands are trellised porticoes, with pylons surmounted by eagles and vultures with extended wings, which produce a very graceful effect.—L'Illustration.



THE FIRST AERODROME IN THE WORLD. "PORT AVIATION," NEAR PARIS.

A NEW DEVELOPMENT IN THE ART OF INDIRECT COLOR PHOTOGRAPHY.

By FRIEDRICH LIMMER.

THE Lumière autochrome plate for indirect color photography represented a marked step forward worthy of the highest commendation. It was an advance which only those can fully appreciate who have themselves worked in a similar field, and who know what perseverance and attention to detail are required in the field of color photography for every small improvement.

The autochrome plate has in a short time made a triumphant tour around the world. While professionals and amateurs have been rejoicing in this the latest development of color photography, Mr. Jan Szczepanik (known as the inventor of the three-layer paper) has filed (August 14, 1907) a patent application for a process which promises to be of great importance for indirect color photography. If the new method fulfills the expectations which seem to be rightly placed upon it, it should prove a strong rival to the Lumière process.

It may be well to briefly describe the autochrome plate. This name has been given to a photographic plate manufactured by Lumière in Lyon. By means of this plate a nearly color-true image of a colored object can be made by one single exposure. The essential feature of the autochrome plate is a tri-colored grain-film prepared in a most ingenious manner. Starch granules colored blue, green and yellow, and mixed in a definite proportion, are dusted over a specially prepared plate. The unavoidable interstices between the individual starch grains are filled out with a black material. The sensitiveness to light of the autochrome plate is comparatively small. This is partly owing to the imperfectly transparent character of the starch grains, but the black filling-in material, of course, also absorbs light. These two drawbacks are absent from Szczepanik's tri-colored film. The following is an extract of the essential points of the patent specification.

Szczepanik bases his new process on the law of "migration of colors." This law is empirical; no satisfactory explanation seems to have been offered for the same. Certain coloring matters show a preference for certain substrata. Thus, if a layer of collodion colored red with erythrosin is placed over a colorless layer of gelatine, the erythrosin "migrates" (almost) completely from the collodion into the gelatine. It has been observed that (with few exceptions) basic dyestuffs show a marked preference for collodion, acid dyestuffs for gelatine. Thus, as soon as the opportunity is given, acid dyestuffs "migrate" from collodion into gelatine, and basic dyestuffs from gelatine into collodion.

There is a class of substrata which behave toward coloring matter in somewhat the same way as does collodion, while another class acts much like gelatine. Among the latter is, for instance, powdered gum arabic.

Szczepanik prepares three solutions of gelatine or gum arabic. Each solution is colored with a suitable dye, and is then cautiously evaporated to dryness. The particular dyes used must, of course, have a preference for collodion. The "solid" masses of gelatine or gum arabic obtained by evaporating the solutions are finely powdered, and the three powders of different colors are carefully mixed. The mixture of these colored powders is then sifted over a slightly moist collodion plate by means of a special apparatus. The coloring matters migrate from the gelatine powder into the collodion film, producing a mosaic of small colored patches similar to the starch granules of the autochrome plate. The powder originally dusted on the plate, which has lost its color, is washed off.

It may happen that particles of the powder overlap on being dusted on the plate. Nevertheless no transfusion of color between the individual particles themselves takes place. The overlapping particles are washed off subsequently together with the spent particles. Owing to imperfect contact between the powder and the collodion film, colorless patches are apt to be formed here and there. This may be remedied by using a little less of one of the colored powders than is actually required. The plate is then, after dusting over, placed in a bath of a gelatine solution of that dye of which an insufficient quantity was used previously. In this way the uncolored patches also are properly pigmented.

According to this process of Szczepanik, a tri-colored film is obtained which has a number of obvious advantages over the autochrome film. It is considerably more transparent than the latter. It contains no kind of filling-in material. Every color patch is directly contiguous with its neighbors. The advantages gained are:

"Greater sensitiveness to light. Increased brilliancy and brightness of the pictures. Freedom from parallax—a matter of much importance in preparing copies from the plates."

The new plates are not as yet upon the market. If they make their appearance and fulfill the inventor's expectations, Szczepanik's process represents a further advance in the field of indirect color photography.

Szczepanik's ingenious application of the law of migration of colors should prove of interest for quite a number of branches of industry.—Translated from the Zeitschrift für Angewandte Chemie.

POLES FOR POWER TRANSMISSION.

THEIR DESIGN AND STRENGTH.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

DESPITE the rapidly increasing developments in the overhead distribution of electric current at high pressures, hitherto but little data has been available concerning the strength of wooden poles on which the transmission lines are carried, with the result that in some countries the elaboration of overhead carrying systems has been severely restricted, thereby severely handicapping the progress of distributing electrical power upon an extensive basis to industrial districts. Especially is this the case in Great Britain, where the Board of Trade, which has control of such work, has hitherto stipulated the very high wind pressure of 30 pounds per square foot and a factor of safety of 10. Under such circumstances it was somewhat difficult to settle precisely the size of pole that should be adopted for a given line; and in order to fulfill the government conditions, care was observed

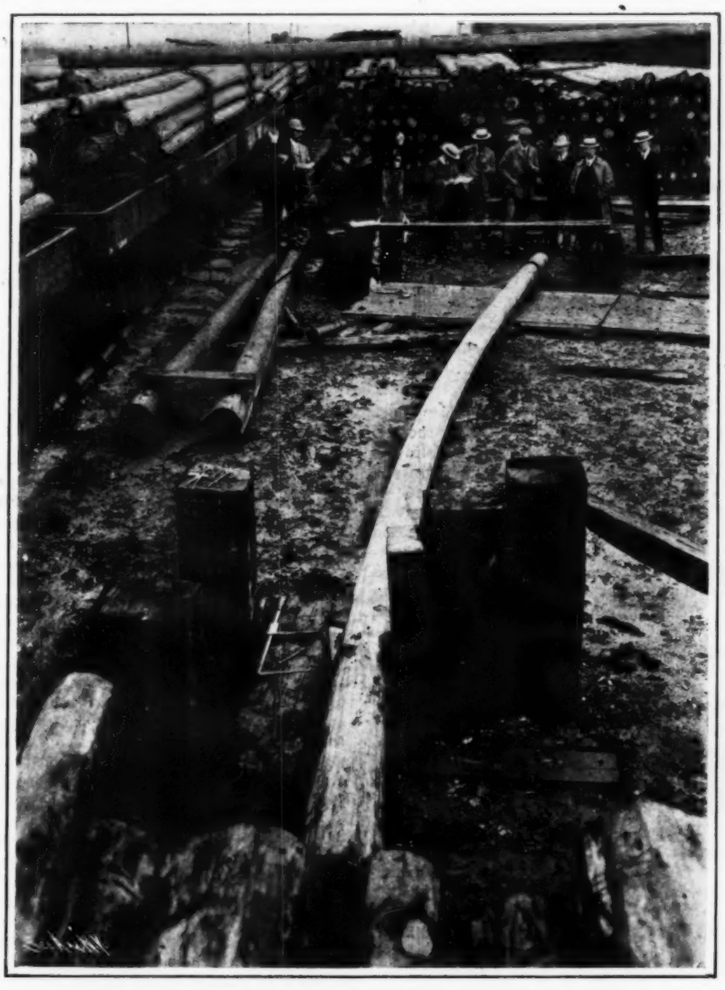
THIRTY-TWO-FOOT A-POLE UNDER TEST. NOTE TWIST OF COMPRESSION LEG AND SKEWING AT TOP.

to err on the side of safety, with the result that the pole-carrying system has been somewhat more elaborate than the exigencies require. In many instances, owing to these factors in regard to wooden poles being an unknown quantity, distributing companies chose to incur additional expense in laying their distributing mains underground, which enhanced expenditure naturally tended to maintain higher prices for current than would have been possible had the distribution system been carried out on the cheaper overhead system.

Realizing that such considerations pressed somewhat unduly upon the electric power producing and distribution industry, Mr. A. P. Trotter, the electrical adviser to the Board of Trade, suggested to Mr. C. Wade, a member of one of the largest firms in the country supplying wooden poles for telegraph and telephone services, that a series of exhaustive tests on wooden poles of varying form, lengths and diameter should be carried out, in order to determine the breaking load, wind pressure, deflection, etc., that the poles can stand, and to embody the scientific results thereby obtained in such a manner that an electrical engineer can determine at a glance what size and type of pole is necessary for any prescribed line. These tests were forthwith carried out at the Hull yards of the firm by Prof. Goodman of the Leeds University, assisted by the engineers of many of the most important power-distribution concerns of the country. Trials were conducted with both single and A-poles.

The principle upon which these tests were carried out may be gathered from the accompanying illustrations. The breaking point of a pole appears to be about 5 feet above the ground, or 10 feet from the butt. In order to obtain conditions similar in character to those prevailing when a pole is erected, the lower end of the pole was anchored rigidly in a timber housing for a length of 5 feet from the butt, corresponding to the depth to which it is sunk into the ground. Four 13-inch square balks were driven to a considerable depth into the ground, and stayed to insure absolute stability. The butt of the pole was then laid in this housing, and tightly wedged in position. At the other or free end of the pole a chain was attached running to a set of pulley blocks operated by hand, a dynamometer being inserted in the loading chain to determine the strain imposed. In order to insure the results being absolutely correct, Prof. Goodman introduced a telescope attached to the butt of the pole, and by which means it was possible to sight a plumb bob at the free end of the pole, so that any slip in its housing could be easily detected and allowed for. The employment of the telescope in such a test as this is a highly essential refinement, and its provision proved so useful that it was adopted in every test carried out. When all was ready, the load was applied to the top of the pole by hauling on the load chain as shown in the illustration, and in some instances the pole, which projected from its housing for a distance of 35 feet, deflected 13, 14, and 15 feet before breaking, while those that were released before the breaking point was reached showed a very slight permanent set.

With regard to the tests of the A-poles, a different method of housing had to be adopted to obviate any tendency to slip. All the poles selected were from 7½ to 8 inches in diameter at a point 5 feet from the butt, and in each instance were of red fir. The double pole, scarfed and with the feet spread out to the desired angle ready for erection, was laid in the housing, and at a point 2 feet 6 inches from the butt two heavy blocks of timber were bolted thereto, one below and one above the legs of the members against the faces of the vertical supports of the anchorage. A heavy iron ring was also bolted to the tension leg of the pole below the blocks, to prevent them slipping down when the load was imposed, while the feet of the pole rested against a massive timber balk supported on the vertical timber supports. Further stability was insured by the insertion of a block between transverse members of the anchorage on the compression pole side. The effect of this arrangement was that when the load was imposed, the leg of the pole under tension was unable to move away from the balk and its supports, owing to the cross timbers, while similarly the leg under compression was unable to move, as its foot was pressing against the transverse member. The pole was thus held with absolute rigidity in position in its housing, the security in this direction being obviously much greater than prevails in actual practice. As before, the opposite or free end of the pole was sighted by means of the telescope and plumb bob, and the load was similarly imposed by means of pulleys and chains with the dynamometer inserted. The weight of the pole at the top end was carried by a chain hung from a pulley slung from an overhead cross pole supported at either end on tripods, and this



SINGLE POLE UNDER LOAD JUST BEFORE BREAKING.

pulley was guided by a line on either side, and the cross pole fixed as nearly as possible level and in the line of the pole's deflection.

In these experiments it was ascertained that whereas a single pole would deflect a considerable distance before breaking, an A-pole, so long as it held firmly together at the top, would deflect only a few inches. But on the other hand, owing to its design, it is possible to sustain a load across its two members, or in other words at right angles to the line, four or five times as great as that possible with a single pole of the same diameter as one of the two members of the A-pole. In regard to its strength, as might naturally be expected, it is twice as strong as a single pole of equal section, but deflects only half as much.

In the accompanying illustrations it will be noticed that the leg under compression buckled down under the strain of the load, thereby causing the pole to succumb in nearly every instance. This buckling, however, was not attributable to the effect of the load, but the initial sag of this member under its own weight. To overcome this tendency, it would have been necessary to have inserted some central support, but by so doing an element of friction would have entered into the tests, and such might have imperiled the accuracy of the results obtained. The question of this friction was considered, but Prof. Goodman preferred to carry out the tests in the manner illustrated rather than have to take into consideration questions of frictional stresses, although the unavoidable buckling no doubt caused the poles to collapse sooner than they would otherwise have done had the trials been conducted with the poles in a vertical position as prevails in practice. The buckling, however, did not precipitate any signs of breaking at those points, and but for this sag out of the line of pull would undoubtedly have sustained greater loads than those imposed. In almost every instance after release the pole returned to its original position, showing that sagging produced no permanent set in the member. In every case the load was imposed at a point 2 feet from the end of the pole, which is the point where the wind stresses and load are imposed upon the pole in practice.

The sum of these experiments showed that the majority of poles at present in use for carrying overhead transmission lines are out of proportion, some being unnecessarily large, while others are dangerously too small. For heavy line systems the single pole is practically useless, if not dangerous, since it bears very little load. The weakest point of an A-pole, however, is the top, where the two members owing to their shape have a tendency to slip on each other under windage and weight, since the member of the pole which is under tension elongates, and forces itself away from its fellow member which is under compression. Under these circumstances, and in order to obviate this shearing strain as much as possible, it is requisite that close attention should be devoted to the means of scarfing the upper ends and securing them together, this consideration of course being governed by the angle at which the legs are set. It is found, however, that a spread of 4 feet from center to center at the butt on a 32-foot pole, or about one-eighth of the height, is the most efficient spread for all-round working, since although if the spread is increased greater strength will be obtained, the cost of erection and handling ordinarily more than counterbalances the advantage gained.

One of the A-poles which was subjected to the experiments above was subsequently tested again six months later, and in this instance the load subjected was 8,960 pounds, the highest imposed during the tests, and the total deflection was only 14 inches. In this case the structure collapsed finally by the splitting and twisting of the scarf blocks and by the oak cross pieces which carried the load at the foot of the pole, but the two members of the pole were found to be absolutely uninjured.

As a result of these experiments, it is urged that a lower factor of safety than that now imposed might reasonably be advanced by the Board of Trade. Mr. A. P. Trotter himself has stated that where a pole is sufficiently strong to stand the wind pressure brought to bear both upon itself and the wires it carries, and is sufficiently elastic in the direction of the line, the weight of the wires need not be taken into consideration at all. Obviously, therefore, it is only necessary to calculate the total stress on the poles tending to break them due to these conditions, and as a result of these interesting tests a series of tables have been evolved in which these considerations are embodied, by means of which the engineer can readily ascertain the length and diameter of pole that will suffice for the support of any line that he has in hand, the wind pressure allowed being 30 pounds per square foot with 10 as the factor of safety.

NATURE AND TREATMENT OF ALLOY STEEL.*

OUR LEGION ALLOYS AND THEIR USES.

BY DR. JOHN A. MATHEWS.

PARAPHRASING the remark that has been made about books we may well say, of making many alloys there is no end and much study of them is a weariness to the flesh and small profit to the maker. It is hardly necessary at this late day that an article upon this subject should consist of long tables of remarkable physical tests—elastic limits above 100 tons, coupled with the elongation of molasses taffy or illustrated with photographs of steel tied into bowknots and large forgings distorted in shapes that would make the "human snake" turn green with envy. Too often in the past such data have raised bright hopes in the mind of a steel consuming public, and too often results in practice have fallen short of published data and perchance aroused a suspicion that published data always represent freak material and freak treatments or that the photographs represent enlarged photos of wire sizes.

A few generalizations in connection with these recent fascinating developments in the steel industry may serve a more useful purpose and help the user to obtain in practice results equal to those claimed by the maker. Let us then begin with the definition that "steel is a malleable alloy of iron and carbon which has been produced by casting from a fluid mass." Since by this definition all steel is an alloy, what is meant by "alloy" or "special" steels? While these terms are in general well understood, they are difficult to define, though they may be described.

COMPLEX COMBINATIONS.

Two elements, iron and carbon, are all that are necessary to produce steel. Four other elements are always present—silicon and manganese, which are useful and essential, and sulphur and phosphorus, impurities whose effects even in homeopathic doses are by no means negligible. Copper and arsenic, aluminium, oxygen, nitrogen, and cyanides are usually present in minute and negligible quantities. Ordinary steel, by whatever process made, is therefore a wonderfully complex alloy, though often spoken of as though it were an elemental substance. It may contain carbon and manganese from 0.10 to 1.50 per cent; silicon from 0.02 to 0.25 per cent, and sulphur and phosphorus from 0.01 to 0.10 per cent, and the other elements named above which are rarely determined. Its complexity is further increased by the fact that iron and carbon may exist in several different physical conditions or combinations, while the intramolecular possibilities of the other elements are legion.

When to this very complex base material other elements such as nickel, chromium, tungsten, and vanadium are added, we begin to look wise and talk about alloy steels. Steels within the limits of analysis just mentioned serve an enormous number of purposes, and steel of a particular analysis adapted for rails, springs, knives, or gun barrels may in a limited sense be called a "special" steel, but such is not the commonly accepted use of the term.

EFFECTS OF ADDITIONS OF CARBON STEELS.

When we materially exceed the limits just given or add elements not normally contained, such as nickel, vanadium, chromium, tungsten, molybdenum, etc., the product is called an alloy or special steel. Silico-manganese gear steel is an instance of an alloy steel containing no unusual elements but containing some of the ordinary elements in unusual amounts. Its analysis is about as follows: Carbon, 0.50 per cent; silicon, 2.00 per cent; manganese, 0.60 per cent.

In such a case it becomes difficult to decide arbitrarily the percentage at which we pass from a regular to a special steel. Abnormally increasing the ordinary constituents or adding other constituents so changes the properties that new qualities appear and new purposes are served. The effects of such additions are made manifest in various ways which may be summarized as follows: 1. By changing the critical ranges and recalescent temperatures. 2. By modifying the condition in which the carbon exists. 3. By removing harmful occluded gaseous impurities. 4. By combining chemically with iron or carbon or both. 5. Either combined or free, forming isomorphous solutions with iron or separating into distinct microscopic particles. By these means steel is improved or injured, hardened or strengthened, toughened, or embrittled.

Notwithstanding its complexity, it is reasonable to expect, and much evidence has been brought forward to show that steel and its alloys obey the laws of physical chemistry which hold good for simpler and purer alloys, namely, the laws of solution. The problems presented by steel alloys have engaged the attention of the world's leading chemists and physicists, and they have made rapid strides within a generation in elucidating the molecular relations of the elements of steel. They have isolated by ingenious methods many well defined chemical compounds, such as the carbides, phosphides, and sulphides of iron and manganese. It remained for an American, addressing one of the leading scientific societies of our country, to discourse upon carbide of phosphorus (not in our chemistry), carbide of silicon (carborundum), and carbide of sulphur (foul smelling, endothermic and a solvent for rubber) as constituents of steel. As he also sang the praises of imported wares, it may be that we are behind the times over here and that these choice foreign products do contain such compounds. We have seen some American products that might be called "rotten," but they were not characterized by an appreciable odor of sulphide of carbon (CS_2).

ALLOTROPIC MODIFICATIONS.

The complexity of steel from a chemical standpoint is further increased by the allotropic character of iron, and by the fact that carbon and probably sulphur and phosphorus may exist in several conditions or combinations. As iron is cooled from a molten condition, it has been discovered that at from one to three temperatures below its freezing point cooling momentarily stops. For carbonless iron these temperatures are designated as Ar_3 and Ar_2 and occur at about 895 deg. C. and 765 deg. C. When carbon is also present a third well marked arrest in cooling is noted at about 690 deg. C., known as Ar_1—the ordinary "recalescent" point. It is believed by many that the Ar_3 and Ar_2 temperatures indicate transition or critical changes in the nature of iron itself. In other words, that just as phosphorus may exist in two distinct forms, one yellow and one red, so the element iron is supposed to be capable of existing in different physical conditions at different temperatures. At temperatures above Ar_3 we have the "gamma" iron of Osmond, non-magnetic and a solvent for both elemental carbon and iron carbide. Between the Ar_3 and Ar_2 temperatures we have iron existing in its "beta" condition, non-magnetic but not a solvent for free or combined carbon. Below Ar_2 iron is in its "alpha" condition, magnetic but not a solvent for free carbon, but possibly a slight solvent for combined carbon. While some metallurgists do not accept this explanation of the significance of the critical temperatures and ranges, all concede that they do occur, and that other elements added to iron carbon alloys change, obliterate, or modify the temperature ranges, and it is just on account of this that different steels require different temperatures for forging, annealing, and hardening.

TYPES OF ALLOY STEELS.

So much for the nature of alloy steels, and now a few suggestions as to their treatment and a few words as to the various kinds of alloys. The constitution of these products, chemical and physical, for generations remained unknown and a matter of speculation. Tremendous progress has been made of late years in clearing up a few of the obscure points. It was the writer's good fortune to have been initiated into these mysteries by the late Prof. Sir William Roberts-Austen and by Prof. H. M. Howe, recognized pioneers and leaders in the task of making a science of the ancient art of metallurgy.

The first commercial alloy steel, at least the first to make a great name for itself, was Mushet's air hardening tool steel. The next alloys to attract attention were of the structural types, and may be said to have had a public introduction when Riley presented a paper to the Iron and Steel Institute of Great Britain upon iron and nickel. Shortly afterward Hadfield's famous manganese steel was proclaimed and later he has produced many valuable products, especially in the line of armor and projectile steels. Along with the making of the new products has proceeded the study of their properties and methods of heat treatment. To-day a host of devotees, skilled in the sci-

* Iron Age.

ence of heat treatment, apply their knowledge to the manufacture of tools, automobile parts, and machinery to produce results never dreamed of a generation ago.

The principal types of alloy steels are those used (1) for materials of war, (2) for tools, and (3) for materials of construction. The first are mainly alloys of nickel, chromium, and tungsten or combinations of these elements. The makers of these alloys also conduct the heat treatments and guard their methods jealously. Alloy tool steels include air hardening and high-speed steels together with a large number of steels of the "special" class containing relatively small amounts of alloying elements, giving them special characteristics and fitness for particular and severe requirements. One product of this class is remarkable in that it undergoes no change in form upon hardening; moreover, it hardens in oil sufficiently to make a remarkably good tap, cutter, or die.

NICKEL, CHROME-NICKEL, AND CHROME-VANADIUM STEELS.

The alloys receiving most attention to-day are those of the third class—namely, materials of construction, and particularly the automobile steels. These are in general of three kinds—nickel steels, chrome nickel steels, and chrome vanadium steels. Many different analyses are made under each class. The difficulty of producing sound nickel steel, free from pipes and seams, has injured the reputation of this most useful alloy with many users. This difficulty has been greater than need be because certain steel companies have mistaken a quality proposition for a tonnage proposition, and have offered nickel steel at absurdly low prices, wholly inconsistent with uniformity of analysis, careful workmanship and inspection. Discriminating users recognize this fact and are willing to pay a premium for the product of certain mills, because their steels are made in smaller tonnages and units, are more carefully handled from start to finish, are worked under hammers rather than in blooming mills, are made from purer materials and carefully inspected when done. The best is none too good for constructing the vital parts of an automobile, and when a concern has secured the best that the market affords, it has but taken the first step in producing good parts. Next come the forging and machining and the heat treatment, for better or worse. It is money wasted to buy good alloys unless one is willing to study them sufficiently to know how to treat them and then to supply adequate facilities for so doing.

THE NEED OF APPARATUS FOR TESTING.

It is not to be expected that small users will install complete testing laboratories, but a few dollars invested in having occasional tests made will be well spent. There are, however, many large concerns that could and should spend, say, $5,000, for which it is believed the whole or a large part of the following equipment could be obtained: The ordinary tensile machine, a microscope, electrical or gas furnaces capable of fine regulation, a good pyrometer, preferably recording. The tensile machine can also be used for making Brinell hardness tests, spring deflection tests, etc. In addition to these some form of drop testing machine, such as the Fremont, will be found valuable; a vibratory or repetitive impact test is nowadays considered a necessity, while cold bending and torsion apparatus is useful. This equipment will be of small use, unless a thoroughly good man is put in charge—a careful, conscientious man of sound judgment. This man should direct the heating operations in the factory; he should construct furnaces which heat uniformly, and he should exercise eternal vigilance in keeping the pyrometric installations up to par.

It is a remarkable watch that never requires adjustment or repairs; a little attention is devoted to the upkeep of all apparatus and machinery, but the pyrometer is supposed to take care of itself. Too frequently it is never questioned, never calibrated. The best pyrometer of the thermo-couple type should be looked over at stated intervals, especially if in constant use. Protecting tubes should be frequently examined and renewed, and electrical contacts looked over. Occasionally check up the millivoltmeter. Unfortunately there are many pyrometers of the thermo-couple type on the market which cannot be watched too closely. Quite recently I visited two concerns where they were hardening the same grade of steel and doing it well. I asked each concern what temperature it was using. One said 1,300 deg. F. and the other 1,700 deg. F. The actual temperature in both cases was probably 1,500 deg. F. Another so-called cheap pyrometer that I tested departed from the truth over 100 degrees in a month, and another was 50 degrees off when installed. In a lot of six couples tested after being in use some time, three were all right and three all wrong and by varying amounts. If you are going to use pyrometers by all means see that you have good ones and then see that they are systematically tested. Many people buy high-priced alloy steels and get no better results from them than could be had from a carbon steel properly handled. If you cannot afford a good pyrometer stick to the trained eye of a skilled man; and if you have a good pyrometer employ a skilled man, anyway, and consider the pyrometer as an aid. With it you can at least give orders in temperatures rather than in heat colors, and the laboratory and works can meet on an intelligent basis. Pyrometers, like "smoke consumers," are all right if carefully watched and intelligently used. Too often both fail after about 30 days' use.

A CALL FOR CONSERVATISM.

The writer has probably devoted as much attention to the literature and fabrication of alloy steels as any reader of this contribution, and the more experiments and the more practical results he observes the more strongly he believes in the wholesomeness of straight nickel steel and certain of the chrome vanadium types. The ease with which these can be machined, especially in the cold drawn condition, is not least among their advantages. While not wishing to appear behind the times and recognizing the good there is in other classes of alloys, the writer believes the matter has been overdone and new products have not in all cases been sufficiently tried out before being put into actual commercial service. Some discrimination should be used in selling alloys where the user is not equipped to get his money's worth from the material. Heat treatment operations depend upon a solid scientific basis. And by this is not meant that steel essentially of inferior quality can be made to pass muster by heat treatment.

NOTEWORTHY RESULT OF HEAT TREATMENT.

On the other hand, however, it might be said that alloy steel in its so-called natural state, as it comes from the rolls, hammer or drop forge, is almost unfit for automobile construction. Steel which depends upon alloys for a high elastic limit in its natural condition will have much less elongation than the same steel oil tempered and annealed. For example, a chrome steel gave in its rolled condition 158,000 pounds elastic limit and 5 per cent elongation, with 9.4 per cent reduction of area. The same steel oil tempered and annealed gave 153,000 pounds elastic limit, 14 per cent elongation and 52 per cent reduction of area. In other words, the material was transformed from brittle to tough, from treacherous to safe, without materially affecting its elastic limit. A nickel steel similarly treated had its elastic limit raised 20 per cent, with the reduction in area improved and its elongation unchanged.

We have tried to give some insight into the construction of alloy steels, the problems involved, the means by which they may be attacked, and some precautions to be observed in the commercial handling of these valuable products. If anything here written shall increase the respect of the user of alloys for the materials he handles and for the men who produce them, and, better still, if anything herein shall stimulate a greater desire in the user to test and study alloy steel more carefully, and strive for practical results somewhat approaching the maximum potentialities of his materials, the writer's effort will not have been in vain.

POSITIONS OF REFERENCE.

By F. C. VAN DYCK, Rutgers College.

IN order to assign definite values to the distances moved by bodies, or to their velocities, it is necessary to assume positions from which the distances are measured, and with reference to which the velocities are stated. The grounds for choice of the position of reference when kinetic energy of mass-motion is produced are set forth under the heading "Frame of Reference," in Jean's "Theoretical Mechanics," from which I quote: "Thus we see that, in the theorem that the increase in kinetic energy is equal to the work done, it is legitimate to calculate both the kinetic energy and the work done by considering motion relative to the center of gravity only; i. e., the system may be treated as though its center of gravity remained at rest" (page 232). For example, let a projectile be shot from a freely supported gun. If the ratio of their masses is not very large the velocity of each is separately stated with reference to a point fixed relatively to their common center, and the kinetic energy of each is estimated with reference to a body fixed relatively to that center. If the mass of the projectile is relatively very small, some point on the gun may be taken as position of reference because the center of the gun would then remain nearly coincident with the common center of the system, gun projectile.

When work is done against friction causing heat directly, or indirectly by producing eddies in a fluid, mass ratios are of no importance. Even the products of masses count only so far as weights affect the frictions. I borrow an illustration from Crew's "General Physics," page 79:

"If now the train be running uniformly at the rate of 24 miles an hour, we conclude that these opposing forces are exactly equal and opposite to the pull of the engine; and hence that the total force acting upon the train is zero. If steam be cut off the engine, the opposing forces accelerate the motion of the train in such a way as to diminish its speed. When the train comes to rest, the opposing forces become zero; and hence the total forces are again zero and the acceleration is again zero. When the engineer lets on steam the forward pull of the engine is greater than the backward pull of the opposing frictional forces. Hence the motion of the train is accelerated, this time in such a way that its speed is increased. This acceleration will continue until the frictional forces are exactly equal and opposite to the pull of the engine. At this point the acceleration is again zero." It is plain that the force of the engine merely balances the resistances so long as it is exactly equal to them, doing no work on the train which moves in accordance with the first law of motion at a speed imparted by an accelerating force. Also the position of reference may be assumed at either end of a distance selected for computation of work done while the rate of motion is uniform.

The process of lifting results in production of energy of configuration. When a man lifts a stone the first step is to exert, for a brief interval of time, a force slightly in excess of the weight of the stone in order to give it an upward velocity. Then the lifting force is diminished until it is exactly equal to the stone's weight. So long as this equality is maintained the lifting force merely does work against gravity, stretching the lines of force linking the stone to the earth as one stretches the spring of a balance by pulling on the ring and hook. The lifting force proper does no work on either earth or stone. When the stone has reached the desired height the lifting force is made less than the stone's weight until gravity has brought the stone to rest. The product, not the ratio, of the masses of stone and earth counts in lifting. The stone rises, while the lifting force is equal to its weight, exactly as it would rise if both lifting force and weight were suppressed. So far as computation of work is concerned we may measure the distance from plane of earth to plane of stone, or *vice versa*, without regard to disparity of masses, since energy of mass-motion is left out of account.

Thus far only work-equations have to be considered, but equations of moments must also be stated when work is done by means of levers. In any instance of leverage the agent's force is applied, directly or through a rigid connection, in each of two parallel planes (perpendicular to the line of motion), and the derived force which balances the forces of the system is also applied in each of a pair of parallel planes. Usually the axis of moments is taken in that plane which is common to the two pairs. For instance, when a man standing on the earth lifts a stone by a lever he is directly connected to the earth through his feet, and his force is applied directly to earth and to lever, while the derived force (equal to weight of stone) is applied to the lever and also through it to the earth. Hence the plane of the earth, being common to both forces, is the plane of reference for both work-equation and equation of moments, and the axis of moments is where the lever turns upon the earth or some support rigidly connected to the earth. When a man uses his foot as a lever to lift himself the force of the calf-muscle is applied in each of two horizontal planes, passing through heel and ankle-joint respectively. The planes in which the lifting force is applied pass horizontally through ankle joint and junction of toe with earth, so the common plane of reference for the work-equation passes through the ankle-joint. It is generally admitted, even by those who maintain that the axis of moments is at the toe, that the work-equation of the foot is: force of calf-muscle × rise of heel relatively to ankle = weight of man × rise of ankle relatively to toe. The "force at the toe produces no motion"; neither does the force at the ankle, for the relative motion of body and earth is due to an accelerative (not the lifting) force. To the lifting force is opposed the resultant force which links the center of the earth to the center of the body, and this mutual force comes equally from earth and from body, appearing as a downward pressure at the ankle and an upward pressure at junction of earth with toe. If, then, this mutual force may be regarded as the "load" or "weight," it is as truly "at" the toe as at the ankle, and it may be located as required for harmony between the work-equation and the equation of moments. Surely the present vogue of the doctrine of conservation of energy makes work-equations of prime importance.—School Science and Mathematics.

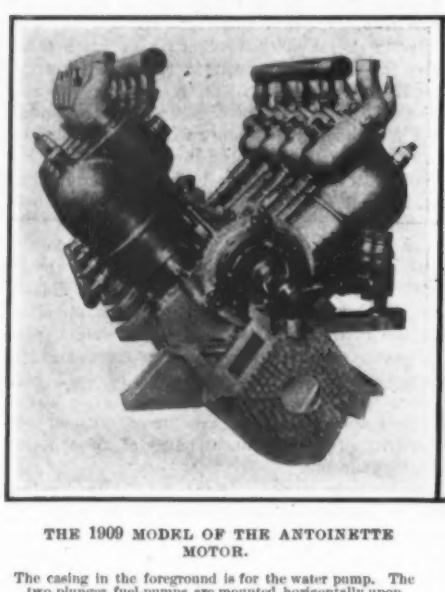
Fossil Meal Fire Lighter.—About 1 part of white or whitish gray infusorial earth (kieselguhr or fossil meal) is stirred with about one-third of a part of plaster and about one-third of a part of gas coke, with water, to a tough paste; place this mass in molds and allow it to dry completely in them. The briquettes taken from the molds are soaked in ordinary paraffine oil, or if this be lacking, for 10 to 12 minutes in petroleum. If one of these bricks is ignited by means of a match a small flame will first appear, which, however, will speedily increase in size until inside of a quarter of an hour it will burn fiercely. Coals can be ignited with one of these lighters without recourse to the ordinary kindling wood.

FOREIGN AERONAUTIC MOTORS.—I.

SOME OF THE LATEST LIGHT-WEIGHT GASOLINE ENGINES FOR FLYING MACHINES THAT HAVE BEEN BROUGHT OUT ABROAD.

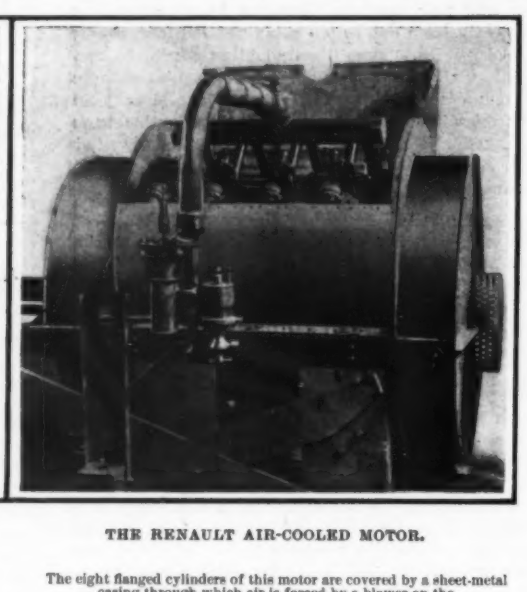
BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

THE tremendous boom that has been given aviation by the success of Wilbur Wright in France has caused the production of a large number of flying-machine motors of different types. These various types will be described in several articles, the first of which deals with the 8-cylinder V type of motor, which is now the most common one abroad.



THE 1909 MODEL OF THE ANTOINETTE MOTOR.

The casing in the foreground is for the water pump. The two plunger fuel-pumps are mounted horizontally upon it, the distributer being back of these on the camshaft. Note the short inlet pipes with small gasoline feed-pipe connections thereon on the top of each valve chamber.



THE RENAULT AIR-COOLED MOTOR.

The eight flanged cylinders of this motor are covered by a sheet-metal casing through which air is forced by a blower on the crankshaft. A single carbureter (seen in the foreground) supplies all eight cylinders.

THE ANTOINETTE MOTORS AND FITTINGS.

The first and most successful motor of this type abroad is the French Antoinette motor. The 1909 motor of this make is a still further improvement upon the motors built heretofore and which have been so largely used upon various aeroplanes. As the new motors present several marked differences in their design from those we have previously described, we illustrate herewith the 55-horse-power motor and give some of the leading details of construction. The motor shown has on its crankshaft a new form of propeller which is described in detail below.

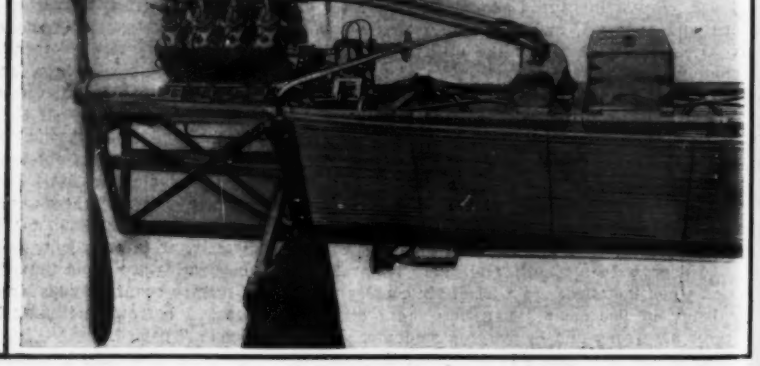
It will be remembered that in the former type of Antoinette motor, the cylinder and the head containing the valves were cast separately and in two pieces. It was found an advantage to use this construction in order to be able to do the machine work upon the cylinder and the valve cage separately, and in this way a considerable degree of lightness was obtained. The new motor departs radically from the former design, in that the cylinder and the valve seat form a single piece, so that there is an entire absence of joints in the construction. This piece is of steel, but as a steel casting could not be made sufficiently thin and light, a drop forging is employed. The cylinder is machined inside and out. The valves are placed one above the other in chambers on the uppermost facing parts of the cylinder heads. The inlet valves are automatic, and the exhaust valves mechanically operated from a single camshaft located in the top of the crankcase between the cylinders. The exhaust pipes extend upward between the cylinders, while the inlet pipes are simply short vertical elbows, to each of which is attached a small copper tube extending to one or the other of two plunger pumps that inject the fuel to the proper cylinders just over the inlet valves. These pumps are operated by variable-throw eccentrics, and their stroke can be varied by turning the hand wheel seen back of the motor. The speed of the motor can therefore be varied by varying the fuel supply. The spark plugs are to be seen in the cylinder heads, as well as the wires running to the distributer, which is used with a spark coil and storage batteries. The water jackets are of pure copper deposited *in situ* by electrolysis. There are no joints whatever, and they are very light and strong. The method of attaching them to the cylinders is patented. The water pump is placed at the rear end of the crankshaft in a special casing. A pulley on the rear extension of the pump shaft is used to drive, by means of a belt, a smaller water pump at the bottom of the panel of condenser tubes which forms part of the triangular body of a monoplane. This condenser is made up of a large number of very thin copper tubes less than ½ inch in diameter. These tubes are very light and flexible. Their weight alone is 8/10 of the weight of the complete condenser, while the headers connecting the tubes together represent the remaining 2/10. Back of the motor is mounted horizontally a cylindrical tank which serves as a separator for the water and the steam coming from the water jackets. At the top of the separator tank there is a pipe which leads to the condenser and which carries off the steam that collects in the upper portion of the tank. The steam passes thence into the top of the condenser, where it is condensed, and the resulting water of condensation is returned to the tank by the pump at the bottom of the condenser. This arrangement makes it possible to reduce the water carried to a minimum, and only three gallons are carried with the motor and outfit shown. The 50-horse-power engine will vaporize ¼ gallon a minute, and the condenser is able to take care of this with ease.

Owing to the fact that the condenser can be readily given a curved form if desired, it can be mounted against the aeroplane surfaces if necessary. When mounted along the body of the aeroplane, which is perhaps the preferable position to be adopted, it presents scarcely any additional resistance to the air when the aeroplane is in flight, and this gives the panel form of condenser a decided advantage.

Mounted upon the motor will be observed the new form of propeller, which is one of the recent improvements made by the Antoinette Company. It is a two-bladed propeller of very light yet substantial construction. The aluminium blades are mounted upon flattened steel tubes which fit into tubes projecting from the hub, so as to allow of fitting the blades quickly and easily to the hub. This new propeller possesses about the greatest degree of lightness to be had with the requisite strength. Having an outside diameter of 2.20 meters (7.21 feet) and a pitch of 1.30 meters (4.26 feet), it operates at 1,100 revolutions per minute as the normal speed. Owing to the design adopted, it is an easy matter to change the angle at which the blades are set. In consequence of this the pitch can be changed as desired. This is a very desirable point in connection with aeroplane testing, as it is possible to experiment and to find what is the best pitch for any given aeroplane or motor speed. From the above it will be seen that great attention has been given to the designing of the new

THE RENAULT WATER-COOLED AERONAUTIC MOTOR.

This motor is an excellent example of the water-cooled type. Note the large water pipes on the sides and top of the cylinders, the fan blades on the flywheel, and the magneto mounted crosswise at end of crankcase.



A 50-HORSE-POWER ANTOINETTE MOTOR MOUNTED ON THE BODY FRAMEWORK OF A MONOPLANE.

The propeller is mounted on the incased projection of the crankshaft at one end and the water pump at the other. The water is circulated through the cylinder jackets and the tank, any steam that is produced being condensed in the tubes along the side, and the water being raised to the tank by the small pump below. The hand wheel back of the motor regulates the fuel supply.

FOREIGN AERONAUTIC MOTORS OF THE 8-CYLINDER V TYPE.

aeroplane power plant, and this will no doubt meet with even greater success than the preceding type, with which both Farman and Delagrange first flew successfully.

THE FIAT AIR-COOLED MOTOR.

One of the most recent of the 8-cylinder V-type motors is that designed by the Fiat automobile firm of Turin. The cylinders, which are mounted separately upon an aluminium crank case, are of a special grade of cast iron. Wide heat-radiating flanges are cast upon the upper part of the cylinders and also upon the valve chambers. These latter are arranged so that the valves rest horizontally in them although the cylinders are inclined at an angle of 45 degrees with the vertical. All the valves are mechanically operated from a single camshaft, adjustable rods and levers being used for the purpose. Ignition is carried out by two high-tension magnetos, and the lubrication is of the automatic force-feed type. A single carbureter placed between the sets of cylinders is used. The exhaust outlets are horizontal. The motor is inclosed in a cylindrical casing of sheet aluminium, the upper part of which is removable. On the crankshaft at the starting crank end is mounted a fan which gives a cooling draft through the casing. Normally this motor, of 110 millimeters by 105 millimeters (4.33 x 4.133 inches) bore and stroke, gives 35 to 40 horse-power at 1,700 to 2,000 revolutions per minute. It will give a maximum of 45 to 50 horse-power. The total weight of the motor, including the carbureter, fan, and outer casing, is about 1,460 pounds.

THE RENAULT AIR- AND WATER-COOLED MOTORS.

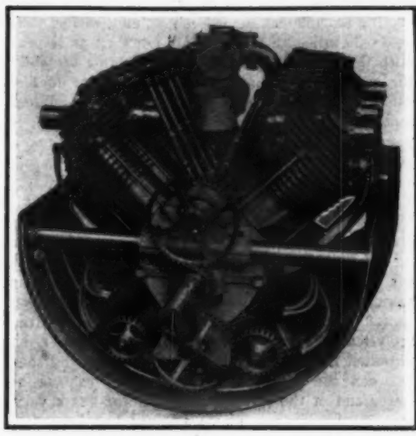
The Renault firm has brought out an 8-cylinder V-type motor, in both the air-cooled and the water-cooled form. As to the air-cooled motor, it is of 45 to 55 horse-power and has eight cylinders with heat-radiating flanges. The bore and stroke are 90 x 120 millimeters (3.543 x 4.724 inches) respectively. All the valves are mechanically operated from a single camshaft, the exhaust valves being placed above the inlet valves. An automobile-type automatic carbureter entirely of aluminium is used and high-tension magneto ignition is also fitted. The lubrication is effected by a set of sight-feed oilers supplied from a tank by gravity with the assistance of slight air pressure. The inlet piping is disposed between the cylinders so that it is warmed somewhat and the fuel is thus properly vaporized. The cooling is augmented by a fan of large diameter, which forces air through the chamber formed by the cylinders and their covering case of sheet metal. As the air can escape only after passing over the heat-radiating flanges of the cylinders, good cooling is secured in this way. The motor develops over 55 horse-power at 1,800 revolutions per minute (its normal speed is 1,500 revolutions per minute) with the camshaft running 900 revolutions per minute. This latter shaft is designed so that a propeller can be mounted on it. On an official test the motor ran as high as 58 horse-power as shown by a dynamometer. With the magneto, carbureter, and air-cooling outfit it weighs 374 pounds, or 6½ pounds per horse-power.

For the water-cooled motor the mounting of the eight cylinders is about the same. Each pair of cylinders is incased in a water jacket. The bore and stroke are the same as the above, and also the capacity of the motor—55 horse-power. It runs at a standard speed of 1,200 revolutions per minute, which corresponds to 45 horse-power. A regulating device on the gas inlet allows of reducing the speed as low as 200 revolutions per minute. Fan blades on the periphery of the flywheel aid in cooling the motor.

THE PIPE AIR-COOLED MOTOR.

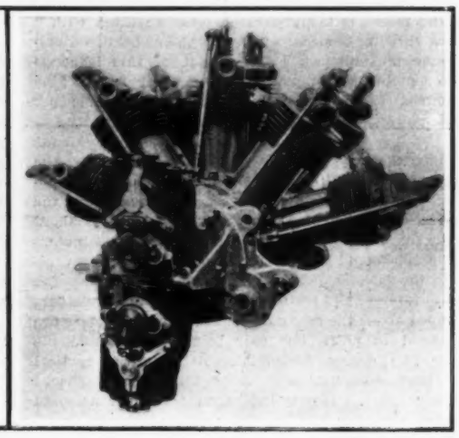
Another 8-cylinder, V-type, air-cooled motor has been brought out recently by the Pipe Company, the well-known automobile and motor manufacturing concern of Brussels. This motor, a photograph of which is reproduced herewith, is designed to give from 50 to 70 horse-power at speeds of from 1,200 to 2,000 revolutions per minute. Four cylinders are mounted in pairs upon opposite sides of the crank case, and at an angle of 90 degrees with the four opposed to them. The cylinders have a 100-millimeter (3.937-inch) bore and stroke. The crankshaft is mounted upon ball bearings, and there is a third bearing in the cross partition in the middle of the crank case, in addition to the two outside bearings. A ball thrust bearing is also placed beside one of the end bearings. The crankshaft has an elastic limit of 120 kilogrammes per square millimeter (85 tons per square inch) and a breaking strength of 150 kilogrammes per square millimeter (106 tons per square inch) with a very marked elongation value. The camshaft is also mounted in three ball bearings which, like the main bearings, are of a patented design and made of an extra hard steel. The camshaft is made in a single piece. Attention is given to securing extra lightness for all the moving parts such as the connecting rods and pistons. A noteworthy feature of this motor is the combined inlet and exhaust valve. This valve resembles that used on the R. E. P. motors and described in SUPPLEMENT No. 1671. It consists of a sliding sleeve, *S*, that is bell-shaped at its lower end in order to form the exhaust valve and, at the same time, a seat for the inlet valve. This latter valve, *G*, is concentric with the sleeve, *S* (its stem, *R*, passes up through the hollow stem of *S*) and it seats upon it at *H*. The seat for *S* in the cylinder head is at *J*. The two valves thus formed are provided with suitable springs and with operating levers *O O'* and *P P'*. The lever *P* is forked so as to surround the stem *R* and bear upon the cap *V* that surmounts the sleeve *S*. The sleeve *S* forms a piston and is provided with two rings just below the inlet ports *DD*. This is for the purpose of keeping the burning exhaust gases from leaking into the inlet pipe when they are being expelled through the exhaust ports *E E*. The operation of the valves is as follows: When inlet valve *G* is opened by rocker arm *O*, gas is drawn in from the carbureter through ports *D D* and down through the hollow sleeve *S*. At the end of the working stroke, the sleeve *S* is moved downward away from its seat at *J* by the forked rocker arm *P*, and the exhaust gases are expelled through the exhaust passages and ports, *E E*. The arrows indicate the course followed by the gases in both cases. The cool fresh gas passing through the center of the sleeve or exhaust valve tends to keep this cool and free from warping. Hence this type of valve is especially useful on air-cooled motors, where the tendency of the exhaust valves is to overheat.

A blower of special design is used for cooling the



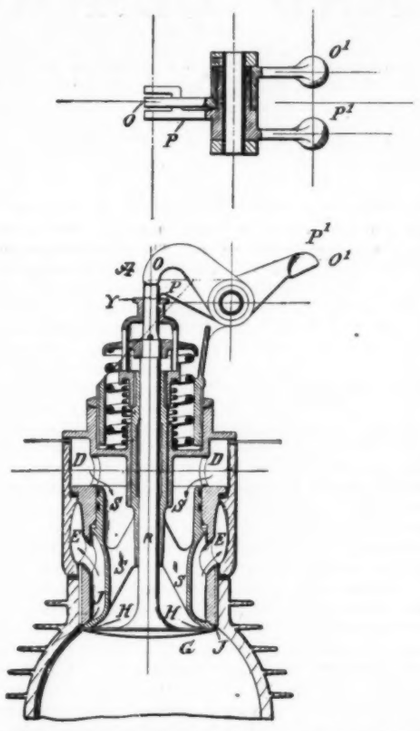
THE FIAT, AN ITALIAN AIR-COOLED MOTOR.

The arrangement of the valves horizontally in the inclined cylinders is the chief peculiarity of this motor. Two magnetos are also employed.

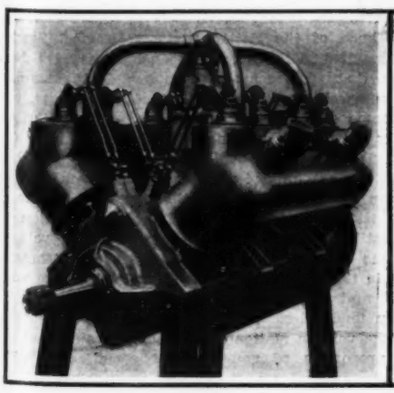


END VIEW OF PELTERIE MOTOR.

This view shows very well the fan-like arrangement of the cylinders and the two magnetos on the crankshaft.

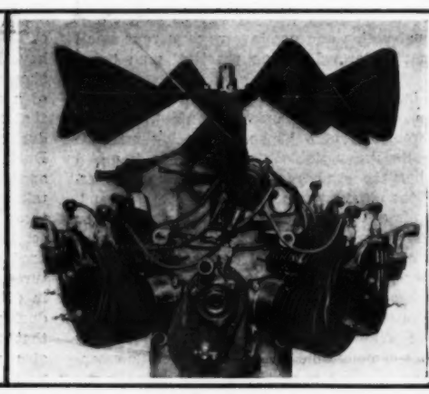


COMBINED INLET AND EXHAUST VALVE OF THE PIPE MOTOR.



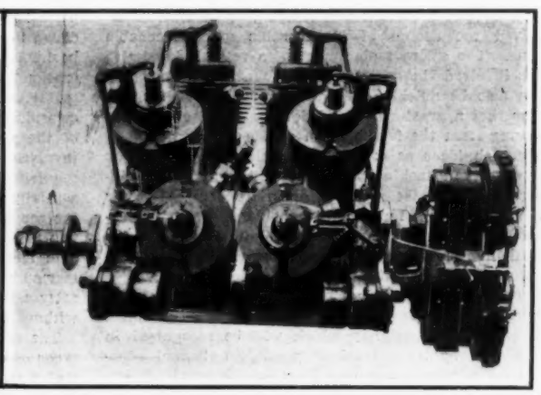
THE PIPE, A BELGIAN AIR-COOLED MOTOR.

The cylinders of this motor are provided with air jackets through which air is blown by a blower on the crankshaft. The engine also has a novel combined inlet and exhaust valve.



FARCOT CYLINDRICAL-TYPE AIR-COOLED MOTOR.

In this motor the cylinders are set in a circular arrangement around the crank case, the draft of air from a fan being depended upon to keep them cool. A combined inlet and exhaust valve is used.



SIDE VIEW OF PELTERIE 10-CYLINDER MOTOR.

The five cylinders on the right and left of the center transverse line of the crank-case form two separate motors. A combined inlet and exhaust valve is used and the two magnetos are seen on the right-hand end of the crankshaft.

FOREIGN AERONAUTIC MOTORS OF THE 8-CYLINDER V TYPE.

flanged cylinders. This blower is mounted on the crankshaft, and it sends a powerful air current around the cylinders through the aluminium air-jackets. Very efficient cooling of the cylinders is obtained in this way, which is the same method as is used upon the American Frayer-Miller automobile engine. Mounted on the motor is a high-tension magneto fitted with a spark shifting device. A special type of float-feed carbureter is employed. The weight of this 50-horse-power motor in complete running order is 131 kilogrammes (288.8 pounds), or about 5¾ pounds per horse-power.

THE R.E.P. AIR-COOLED MOTORS.

Since the type which we illustrated last year, the Robert-Esnault-Pelterie (R.E.P.) motor has been improved and changed in some respects, while keeping the general arrangement of the cylinders fan-wise about the crank case. Three principal types of these motors are of 25, 35, and 50 horse-power respectively. We illustrate the 50-horse-power type herewith, as it has the most interesting features, including ten cylinders grouped about the crank case. Six of the cylinders are arranged in pairs, one pair being vertical and the other two nearly horizontal. Between the vertical and each horizontal pair, is an inclined pair spaced farther apart. The cylinders on the different sized motors are all alike, having an 85-millimeter (2.806-inch) bore and a 95-millimeter (3.74-inch) stroke, and the only difference being that the 25-horse-power motor has five cylinders, while the 35-horse-power has seven. The 50-horse-power motor is practically two 25-horse-power motors mounted side by side, upon a single crank case. In the R.E.P. motors the cylinders, of cast iron, are air-cooled while the pistons are of steel and are carefully fitted. A combined inlet and exhaust valve for each cylinder is worked by a rod and lever device from the camshafts, of which latter there is one for each set of five cylinders. A central bearing is used in this sized motor for the crankshaft. Each set of five cylinders has its carbureter and piping. Air cooling is sufficient for the motor, and, except at speeds below 30 miles an hour, an air fan such as is provided with the outfit is not necessary. Outside the end bearing is mounted a Simms-Bosch magneto of double type for the ignition. The weight of the 50-horse-power motor in running order, not counting the fan, is 215 pounds, which is a weight of but 4.3 pounds per horse-power.

THE E. N. V. MOTOR.

Still another new aeronautic motor of the 8-cylinder V type is that known as the E. N. V. The bore and stroke of the cylinders and pistons are 100x130 millimeters (3.937 × 5.118 inches) respectively, and the motor develops 50 horse-power at 1,000 revolutions per minute. Its weight per horse-power varies from 6.6 to 3.6 pounds. The cylinders are fitted with electrolytically-deposited copper water jackets, a special patented feature being the method of making the joint between the jacket and the cylinder casting at the lower end of the cylinder. The motor has a very substantial appearance, as no attempt has been made to depart from standard automobile practice in order to obtain lightness, as far as the valves and other essential parts are concerned.

An English engine of this type, designed by Mr. W. L. Adams, has lately been brought out in that country. This engine is also water-cooled, the cylinders being provided with corrugated copper jackets. The valves are placed side by side in the cylinder heads, and each pair is operated by a single rocker lever pivoted between them and worked by a rod extending upward from the camshaft in the top of the crank case. Straight inlet pipes run across each set of four cylinders and are connected together by a single cross pipe at their center points, the carbureter being attached to the center of the cross pipe. The carbureter has eight jets, which are uncovered one by one as the throttle is opened. The cylinders have auxiliary exhaust ports consisting of a number of small round holes in each. A compression of 130 pounds is said to be used. The bore and stroke are 4 x 4¾ inches. Both the crankshaft and camshaft are mounted on ball bearings. The water pump and magneto are on a transverse shaft at one end of the motor. The magneto runs at twice the speed of the engine, and as a result of this it can fire all eight cylinders. The weight of this engine, exclusive of the magneto, water, fuel, and oil, is said to be 452 pounds, and the brake horse-power claimed for it at 2,000 R. P. M. is 113. The weight of the flywheel is 55 pounds, and of each piston with its connecting rod and brasses 6½ pounds. The hollow crankshaft with all bearings and the connecting rods, caps, bolts, and nuts is 103 pounds, and the aluminium casings and other parts 180 pounds. If this motor will develop the power claimed, and if the weight is as stated, its weight per horse-power is only 4 pounds.

Another British 8-cylinder engine, which, however, is of the air-cooled type, is that known as the J. A. P. The cylinders of this engine are of cast-iron with perforated heat-radiating flanges. All the valves are mechanically operated from a single exposed camshaft mounted upon the aluminium crankcase.

DETACHABLE AND DEMOUNTABLE RIMS.

THE QUESTION OF AUTOMOBILE TIRES.

BY HERMANN F. CUNTZ, M.E.

THE question of rims for automobile tires is to-day a very important item. Until a few years ago there was still uncertainty in the minds of many as to whether the pneumatic tire, substantially in its present form, had come to stay, or on the other hand, whether it would be superseded by something radically different. To-day the practical men of the industry give little heed and waste no time on the idea of radical changes. For the large class of automobiles now in use, the pneumatic tire is evidently the means *par excellence* of supporting the vehicle on any kind of road. A small percentage of automobiles, such as slow-going trucks, are better equipped with solid tires, but here the rubber tire still reigns supreme and gives promise of continuance.

Having this main problem disposed of, and it might be said settled by usage, the manufacturer has turned to the question of ready repair, and in the case of the large, heavy automobile tire, this, after various vicissitudes, has settled down to the question of quickly removing the tire and repairing it or replacing it. The replacing has in fact become essential because of the increased use and the great prospects in the near future of automobiles for service where "time is money."

Having narrowed down to the replacement of tires, the question has been one of taking the tire off and putting a new one on and inflating it or carrying an extra ready-inflated one equipped with a rim, so that it can be substituted for a deflated tire in the quickest possible time. The question of quickly removing tires or rims and replacing and blowing them up, has involved the design of innumerable quick-detachable rims. The entire replacement of a ready-inflated tire has involved the question of demountable rims which can also be quickly remounted upon a wheel. It is true that a great variety of devices and designs have sprung from the fertile brain of the inventor, involving such ideas as complete replacing of a wheel, as well as the attaching of a separate tire and rim without taking off the ruptured or injured tire. But for the present and for general consideration, the quick-detachable rim and the demountable rim are the practical, live problems of mutual interest to the tire and automobile manufacturer at the present date.

The quick-detachable rim is now being thoroughly tried out in several forms, any one of which promises to establish superiority which will be recognized in due time by its general or possible universal adoption—a millennium in this detail of the multitudinous ramifications of the industry, which is looked forward to anxiously by all, including the two hundred thousand and more users of automobiles in the United States, and frequently more desired by their friends or the users of automobiles for hire.

The demountable rim is therefore left for prime consideration at this very moment. It is generally accepted that the quick-detachable tire has its field and the demountable tire its field. It is possible, however, that some very advantageous combination of the two will be the solution of the vexed problem.

Years ago in the bicycle days, when the question of cushion tires or pneumatic tires was the live issue, the single-tube tire was supreme, and the question of securing it to the rim received much time and study; in fact, the exact nature of the shellac used to attach these tires to wooden or other bicycle rims, and the method of attaching them, were considered valuable items in the knowledge of bicycle construction. The clincher tire in those days received little more consideration than a double-tube tire, with an outer casing attached in much the same way as a single-tube tire or hose pipe.

In 1899 the construction of numerous heavy automobiles caused a sudden activity in the development of very heavy pneumatic tires, which resulted in such stiff walls and beads in clincher construction as to necessitate the development of attaching means to handle replacements and repairs readily. Constant development, however, has resulted in a deep-seated belief in the advantage of the simplest form of single-piece clincher rim, a band of metal with each edge turned up to hold the clinch or bead of the tire casing, and the use of some means which will securely hold that rim on the felly band of a wheel in a manner which will be, in the first place secure, secondly will permit ready removal, and thirdly will be simple and cheap in construction and not involve numerous small parts, frequently termed by the practical man "gimcracks."

But even in the demountable rim there is some subclassification which has become recognized, in view of the different use of vehicles. A racing machine involves in its demountable rim the above itemized requisites, but the ready-removable feature must essentially be the quickest possible. On the other hand, for general pleasure use the difference of a minute or two is not so important as a construction of demountable rim which will not stick, or, as it is usually termed "freeze," but will permit ready removal even after a rim has been on a wheel one or many months without any attention.

The racing of automobiles has brought about many types of quick-demountable rims, but the details essential for quick removal have not always afforded the best results for other kinds of use. Furthermore, a racing car driver is essentially a mechanic, and a tire that would eminently suit his purpose would not necessarily be the most readily handled by the average user of automobiles. All these considerations, and others too numerous to mention in this brief review of the subject, brought before the public at the automobile shows of 1909 a startling variety of structures, in almost all of which there were one or more features of unquestioned merit. It would appear from the time and money that have been spent on the problem, that the early part of 1909 is likely to see combinations of the several meritorious features of different designs, to produce a generally, or even universally, accepted form of demountable rim. On the other hand, the indications would lead one conversant with the dreams of many inventors to believe that there is still the possibility of a form of demountable rim quite different from those developed in the past or even at the present time.

The public, as well as the automobile manufacturer and the tire-maker of the country, have before them no less than a dozen or fifteen forms of demountable rim, more or less tried, from which one or two quasi-standard designs may be adopted and come into general use.

In addition scores of designs on paper have been considered and are in process of development, or have been found wanting in merit and discarded. The solution, it is firmly believed, will be the combination of the simplest possible design suitable primarily for general as distinguished from racing use, and then the perfection of that design by those skilled in the manufacturing and commercialization of a structure of this character.

Experiments conducted recently by the Technological Branch of the United States Geological Survey have resulted in the following conclusions: (1) It is shown that some coals liberate gas during storage, of a composition similar to that of natural gas, and that some coals rapidly absorb oxygen from the air during storage without forming carbon dioxide. (2) During drying in air at 105 deg. C., some coals lose appreciable amounts of carbon dioxide, and most coals take up oxygen to a considerable extent; but none of those tested showed any considerable formation of combustible gases. (3) The nature of the volatile products distilled from several coals at low temperatures in the early stages of heating is shown to vary in different coals in accordance with their smoke-producing tendencies. (4) It is shown experimentally that the volatile matter of coal comprises a considerable proportion of non-combustible matter, varying with the type of coal. (5) The temperature in the coal during an official volatile determination was measured, and the composition of the official volatile matter determined. (6) A modification is suggested of Dulong's heat value calculation for coal based on experimental results showing the distribution of oxygen between hydrogen and carbon.

ANCIENT AND POPULAR IDEAS OF COMETS.

QUEER SUPERSTITIONS ABOUT STRANGE HEAVENLY BODIES.

BY IRENE E. TOYE WARNER.

A COMET with historical associations of very interesting character is expected to return to the sun in 1910. It may, therefore, be of some service to give a few ancient and popular ideas as to the nature and supposed mission of these mysterious visitors from the boundless realms of space. It is strange that in the Middle Ages many erroneous ideas were prevalent, especially as the Chaldeans, according to some authorities, were practically modern and correct in their views, their belief being that comets, like planets, move in regular courses, and are invisible at times, owing to their recession from the sun and earth, and that their periods may be known by observation. Seneca also held these opinions, but he was in the minority, as is too often the case with those who are in advance of their age.

The great philosopher, Aristotle, whose writings on many subjects held supreme sway over the civilized portion of the world until the Middle Ages, believed that the heavens were incorruptible and unchangeable, and that comets could not be reckoned as belonging to the heavenly bodies, but that they were only exhalations raised into the upper regions of the air, where they blazed for a time and then were entirely destroyed as soon as they ceased to be visible. Other ancient ideas are equally wide of the truth. Among many that could be mentioned are those of: Metrodorus, who thought they were "reflections from the sun"; Democritus, "a concourse of several stars"; Strato, "the splendor of a star enveloped in a cloud"; Heracletes of Pontus, "an elevated cloud which gave out much light"; Epigenes, "some terrestrial matter that had caught fire and was agitated by the wind"; Anaxagoras, "sparks from the elementary fire"; and Xenophanes, "a motion and spreading out of clouds which caught fire." They were also considered wandering stars (the word "comet" literally means a "hairy star") and meteors, having a purely atmospheric origin.

There are a few allegorical descriptions in the New Testament which imply that the Biblical writers had noticed and knew something about comets. St. Jude speaks of "*wandering stars* for whom the blackness of darkness hath been reserved for ever"; and in Revelation we read, "there fell from heaven a great star, *burning as a torch*"; this expression is frequently used to describe a comet in ancient MSS. Perhaps the very vivid description of the dragon in Revelation served as a type to later writers, who possibly thought that the dire prophecies were being fulfilled by the apparitions they so much dreaded, and thus, in terror, they beheld in the sky the pictures they had conjured up in their imagination and invested with such awful portent. By comparing the account in Revelation with the descriptions of comets which appeared in the Middle Ages we are at once struck with the resemblance. The picture in the sacred book is as follows: "There was seen another sign in heaven; and behold, a great red dragon, having seven heads and ten horns, and upon his heads seven diadems. And *his tail draweth the third part of the stars of heaven.*"

With the acceptance of the Copernican conception of the solar system, that is, the central and controlling position of the sun, man was taught the true and subordinate position of the earth in the universe. This was a blow to his pride, for while the Ptolemaic ideas held sway, the earth was regarded as of primary importance, and the whole heavens and the glory of them as merely created for the benefit of her inhabitants. Possibly it was as much for this very human reason as for a mistaken notion of the teaching of the Scriptures that the Copernican theories did not gain ground very rapidly. It is little wonder, then, that such an apparition as that of an unknown "blazing" star was beheld with awe, and more often dismay, as presaging evil to some potentate or a great calamity to the nations; but sometimes, happily, the idea of its baleful influence gave way to a more healthy feeling, and the comet was regarded as a herald to announce the birth of a great man, or a "pillar of cloud by day and of fire by night" to lead a favorite general on to victory. No doubt clever leaders took advantage of the popular superstition and fostered the belief of their followers that it was an omen of success and a visible pledge of the Divine assistance, thus bringing about the desired result, although from a different reason to that assigned. Diodorus Siculus says (B. C. 344): "On the departure of the expedition of Timoleon from Corinth for Sicily the gods announced his success and future greatness by an extraordinary prodigy; a burning torch appeared in the heavens for an entire night and went before the fleet into Sicily." In the year B. C. 48, during the war between Cæsar and Pompey, Lucanus says that "a comet, that terrible star which upsets the powers of earth, showed its portentous hair."

The fall of famous cities has been connected with the apparition of these dreaded visitors, such as the comet which shone over Constantinople when great misfortunes were impending in the year A. D. 400, and also when the city was captured by the Latins in 1204. The fall of Rome was preceded by a comet, when the Eternal City fell into the hands of Alaric, the Goth. Josephus records that a large comet appeared over Jerusalem when it was besieged by Titus, and that it was visible for a whole year. Another caused great consternation in A. D. 1000, and was thought to announce the end of the world, as this event had been predicted to take place in that year.

Cometary Legends.—In the year B. C. 1194 we are told by Hyginus that "on the fall of Troy, Electra, one of the Pleiades, quitted the company of her six sisters and passed along the heavens toward the Arctic Pole, where she remained visible in tears and with disheveled hair, to which the name of comet is applied." This probably refers to a comet which passed from Taurus to the North Pole. We are informed by Pliny that in B. C. 975 the Egyptians and Ethiopians felt the dire effects of a comet. It "appeared all on fire, and was twisted in the form of a wreath, and had a hideous aspect; it was not so much a star as a knot of fire." It is strange how ignorance invested a truly beautiful sight with such a repulsive and terrifying aspect. According to the same historian a comet in the form of a horn was visible at the time of the battle of Salamis (B. C. 480).

In the legendary history of Merlin, the ancient British enchanter, it is stated that on the appearance of a comet he prophesied that Uter, the brother of Ambrosius, on the death of the latter, should rule the kingdom; that a ray from the comet which pointed toward Gaul presaged a son who should be born to him and who should be great in power; and that the ray "that goes toward Ireland represents a daughter, of whom thou shalt be the father, and her sons and grandsons shall reign over all the Britons." These prophecies were justified by facts, but they were probably written, like so many others have been, after the event.

Comets Which Have "Announced" Birth and Death.—At the birth of Mithridates a comet appeared, which remained visible for seventy days. We are told that "the heavens appeared all on fire; the comet occupied the fourth part of the sky, and its brilliancy was superior to that of the sun." And the same kind of comet is reported to have been visible for seventy days when that monarch ascended the throne. A comet which appeared in A. D. 132 was regarded as the soul of Antinous. In A. D. 858 a comet was seen before the death of Pope Benedict III.; in 869 another announced the death of Lotharius the Younger; in 875 that of Louis II.; and in 877 that of Charles the Bald. A brilliant comet was visible for forty days and forty nights at the time of the Emperor Constantine's birth in A. D. 904, and another heralded his death in 959. A comet which appeared for three weeks in the year 942 caused, according to the chroniclers, "a great deal of mortality among oxen"! Boleslas I. and Casmir, kings of Poland, saw one of these portents before their death. Our own kings were not neglected, for a comet "announced" the death of Richard I., "the Lion Heart," and another that of James II., King of Scotland, in 1460. The Jews thought the comet of 1208 was a sign of the coming of their long-expected Messiah. A brilliant and beautiful comet which appeared in B. C. 40 or 43 was regarded by the Romans as the soul of the great Julius Cæsar endowed with divine honors!

Pliny's Description.—This historian has given us a very quaint description of the different kinds of comets. "Some," he says, "frighten us by their blood-colored mane; their bristling hair rises toward the heaven. The bearded ones let their long hair fall down like a majestic beard. . . . The horse-comet represents the mane of a horse which is violently agitated as by a circular, or, rather, cylindrical, motion." He made a very good guess at the truth in the latter statement, for modern observation has taught us that the tails of some comets do rotate about the nucleus or head. He continues: "There are bristling comets; they are like the skins of beasts with their hair on, and are surrounded by a nebulosity. Lastly, the hair of a comet sometimes takes the form of a lance."

In A. D. 1500 there appeared a "comet of bad omen," which was popularly held responsible for the storm which caused the death of Bartholomew Diaz on his voyage from Brazil to the Cape of Good Hope. There is an extremely thrilling and dramatic account of the comet of 1527, which, I think, was written by an observer gifted with a most remarkable and lively imagination. He says: "The length (of the comet) was of a bloody color, inclining to saffron. From the top of its train appeared a bended arm, in the hand whereof was a huge sword in the instant posture of striking. From the star proceeded dusky raies, like a hairy tail; on the side of them other raies like javelins or lesser swords, as imbrued in blood, between which appeared human faces of the color of blackish clouds with rough hair and beards!" Many people were ill with sheer fright on beholding this truly "awful comet."

Those who prophesied misfortune on the apparition of a comet left themselves a convenient loop-hole of escape if the expected calamity did not take place. If things occurred as they predicted, well and good, and they were regarded as great prophets, but if they did not, then "the prayers of penitence had turned aside the wrath of God," so that whatever happened, the astrologers were right in the eyes of the multitude. They also taught that any event foretold by the comet might not take place for one or more periods of forty years.

In the "History of Prodigies" we read: "These signs and prodigies give warning that the end of the world is come, and with it the terrible last judgment of God," and this idea was held by most people until about the end of the seventeenth century. The comet of 1630 was associated by Ripamontius with a great pestilence.

A very brilliant comet which appeared in 1680 was, perhaps, the last to be regarded as a prodigy. The wildest terror prevailed, some believing that another deluge was coming as "water was always announced by fire." Many people made their wills and gave their property to the Church; while others thought that some person of exalted rank would die. To add to the general panic, it was reported that a hen at Rome had laid an egg on which was drawn the picture of a comet. Bernouilli said at this time: "That if the body of a comet is not a visible sign of the anger of God, the tail may be." Even Whiston considered it possible that the approach of a comet caused the Biblical deluge. Newton, on the contrary, maintained that they were beneficial, and fed the sun with light and heat. He also thought that the most useful parts of the atmosphere were derived from them.

Modern Panics.—In 1773 all Paris was terrified by the approach of a comet which, according to a memoir by Lalande, might come within about 40,000 miles of the earth and cause (through pressure) the sea to leave its bed and cover part of the land. The popular fear subsided when he stated that, in any case, this would not happen until after twenty years. Biela's comet, which returned in 1832, also caused much dismay when Damoiseau found by calculation that it would pass through the plane of the earth's orbit on October 29. The papers immediately concluded that a collision would take place, and that our globe would be destroyed; whereas, as a matter of fact, the earth was about a month's journey from the threatened point in her orbit. Similar scares occurred in 1840, 1857, and 1872. With the advance of science and the spread of astronomical knowledge, all fears have passed away, and there are but few writers left who seriously believe that any terrible calamity would happen, even if a cometary body succeeded in penetrating the dense atmosphere of the earth. In these days, when celestial occurrences are subjected to rigid scientific inquiry, leaving little room for imagination, it is, perhaps, of some interest to quote again the ancient records of the time when men groped for the truth, and lived daily in a world of "wonders" far beyond their powers of description or comprehension; and with every modern discovery of the laws of the universe, our awe but increases until we are constrained to cry: "Great and marvelous are Thy works, and Thy wonders past finding out, and in Thy temple everything saith 'Glory.'"
—Knowledge and Scientific News.

Hardening powders usually consist of mixtures of charcoal and bloodmeal, horn-filings, glue, saltpeter, ferro-cyanide of potassium, etc. A very effective hardening powder may be made by mixing 24 parts of horn charcoal, 4 parts of horn filings, 6 parts of glue, 9.5 parts of niter and 53 parts of common salt.

ELECTRICAL NOTES.

An electric recording target, designed by Mr. Sydney A. M. Rose, A.M.I.E.E., which records each shot, or series of shots, accurately and automatically, is being introduced, according to Engineering. It consists of a traveling target of the usual size, in conjunction with a miniature recording replica of same, located at the firing point. The motions of both the target and replica synchronize, and when the former is hit a mark is recorded on the corresponding part of the replica. The target consists of a paper or paper-covered canvas band, marked with the required aims, and is actuated by an electric device which unrolls the band on one side and winds it up on the other. The endless series of targets can travel in either direction and operates synchronously a roll of paper at the firing-point on which the records are made. Across this paper, and at right angles to the direction in which it travels, is arranged a set of contact-making devices placed 1/16 inch apart, and for individual firing connected through a resistance and a line-wire to the marking mechanism of the recorder. An auxiliary line-wire is provided for synchronizing purposes. For volley firing the contact-levers are each connected by a separate wire to a corresponding pencil or marker. When the target is being used, any hole passing under the contact devices immediately closes a circuit, thus transmitting and reproducing the hits.

The use of an earth return for electric currents presents obvious attractive features, but, except for telegraphy, has not hitherto been generally adopted and has in fact been prohibited by law. In France a commission was appointed in 1902 to investigate the technical feasibility of using earth returns. Their report stated that if only the effects in the soil had to be considered, it would be quite possible to use the method in such a way as to avoid all damage. The commission was not, however, prepared to pronounce an opinion as to the possible ill effects produced by induction upon neighboring circuits. In 1906 experiments were started to elucidate this point, with highly refined apparatus. The Siemens electro-dynamometer used gave a deflection of 40 centimeters for one milliampere upon a scale placed at one meter from the mirror. From the results it appears that the disturbances which may have been caused by earth returns are practically beyond the limits of observation, and are at any rate smaller than those due to so-called earth currents. The complaint is heard on all sides that old monuments and architectural works of art are weathering away rapidly and are threatened with ruin. The cause is well known; the havoc is due mainly to smoke and fumes from factories. These fumes contain sulphur dioxide, which in contact with the moisture and oxygen of the air becomes oxidized to sulphuric acid, the latter corroding stonework of all kinds. Among the structures thus seriously affected is the Cologne Cathedral, the florid decorations of which present a very large surface to the corroding agencies. Mr. Bertel, architect in charge, in a report on the subject can suggest no other remedy than to curtail the industrial activity of the neighborhood. It seems reasonable, however, to hope that the chemist, who invented the cause of the evil, will find the means also of remedying the same by some suitable treatment of the materials affected.

The generation and distribution of electrical energy from hydro-electric power plants is receiving as great an impetus at the present time as any other means for the generation of power. In 1890, the total water-power development was about 1,500,000 horse-power; in 1900, it was 2,200,000, and in 1910 it will be over three million horse-power. Although the cost of installation of hydro-electric plants is considerably greater than that of steam plants, the cost of operation and maintenance is very much less, and the additional fact that no fuel whatever is consumed makes the cost of power generated so much lower than the cost of steam power that energy can be transmitted from these developments for many miles and still be sold for half the cost of steam power, with a handsome profit to the investor. In fact, the available power sites are being taken up so rapidly that the next ten years or so will probably see all of the more profitable possibilities fully developed. This, of course, tends toward a decrease in the total steam power necessary to supply the needs of industry, but the total possible economical development of water power in the United States is only about thirty million horse-power, and there is that much steam power in use at the present time, and at the present rate of increase there would be sixty million in use in another ten years. Thus it is quite evident that the development of the total water power possible would not materially lessen the coal consumption. In fact, if the present rate of increase continues, in but a very few years the price of coal will soar to undreamed-of heights, chiefly because of the difficulty of transporting it in sufficient quantities. The difficulties of transportation are by no means imaginary. They are already upon us, and will become most serious indeed with but a small increase of industrial activities. The result will be a scarcity of coal for power purposes and an increase in the cost of steam power.

ENGINEERING NOTES.

A scheme for securing efficient industrial education which undoubtedly could, in a modified form, be worked to advantage in many of our industrial centers in the United States, has been adopted by a number of English firms. It appears that some municipalities maintain public evening schools especially adapted to the needs of apprentices, but as the expenses for these evening schools are rather too high to be borne directly by the municipality, if efficient instruction is to be given, the local firms have agreed to pay a certain sum for the instruction of each of their respective apprentices who joins an evening class, and monthly reports are forwarded the firms as to the attendance and progress of the students.—Machinery.

The London Times Engineering Supplement, referring to the return to England of Col. Hughes, who represented the Sheffield high-speed steel manufacturers in the recent hearing in the United States of the action recently brought against them by the Bethlehem Steel Company, says: "Should the Bethlehem Company succeed, the effect would be serious on the Sheffield makers of high-speed steels, who export considerable quantities to the United States. An important combination of high-speed steel makers was formed in America just before Col. Hughes came away, so that now practically all high-speed steel makers in this country who have already been associated in defending the action will be joined by a similar combination in the United States."

Referring to the formal abandonment of the attempt to force the reburning of ashes upon the firemen of the New York city school buildings, the Engineering News says: "It was found that the great saving in fuel claimed for the ash-burning scheme did not really exist, and the boiler repair bill was increased. The cooler ends of boiler tubes were clogged and the steaming qualities of the boilers were impaired. The boilers appear to have suffered excessive corrosion while idle, although there seems to have been no very active deterioration while they were kept hot. It is quite true that a great deal of unburned coal has gone into the ashpit in the past; but the remedy for this waste is not in trying to burn the ashes over again with oxalic acid or any other nostrum, but in training the firing force in proper management of these boilers to prevent such waste."

All the steps which have been made so far looking toward economy in the use of steam power and in its generation are really insignificant. The ordinary steam engine does not convert more than 5 per cent of the total energy of the coal into useful work, and in most highly developed modern plants the efficiency never rises above 10 or 12 per cent. We have about given up hope of ever doing much better than this with the steam engine; and it is more than possible that the gas engine, used in connection with producer gas, may revolutionize our methods of converting the energy of coal into useful power and to a large extent replace the steam engine. The efficiencies of the gas engine are more than double the best that have ever been obtained with the steam engine, and the complete demonstration of continuous and reliable operation of the gas-producer plant on bituminous coal will be followed by the general adoption of this source of motive power.

From a note in the Mechanical Engineer it is evident that English mechanics and engineers are also feeling the need of more intimate connection between technical education and shop practice. A committee of the Northern Coast Institution of Engineers and Shipbuilders has made the suggestion that apprentices be divided into two classes, one to be known as "ordinary apprentices" and the other as "pupils," the latter receiving rather more wages and also serving six years' apprenticeship, half of this to be passed in the works and the other half at college. For "ordinary apprentices" it was recommended that preference should be given to those with the highest leaving certificates at the elementary day school, where the committee recommend youths intending to qualify as artisans should receive, when possible, some instruction in elementary science, and that each year they would be given marks for examinations, time-keeping, good conduct, industry, and progress, bonuses being given for exceeding a certain number of marks. The pupil class will be trained to recruit the ranks of draftsmen, managers, superintendents, employers, etc. Those who have passed a three years' course in engineering at a university college and obtained a certificate from it, would be taken as pupils for a three years' course, and in other cases workshop experience and college study would be combined for a period of six years, the pay to be higher after the first year's college course. Ordinary apprentices would be promoted to the pupil class on passing suitable examinations, during the course of their apprenticeship.

TRADE NOTES AND FORMULÆ.

Hoof Cement.—2 parts of gutta percha are softened with pure water and divided into pieces as large as a nut, then melted over a slow fire in a tinned iron pan, constantly stirring, with 1 part of crushed gum ammoniac, until the mass has acquired the color and appearance of chocolate. Before using, the mass must be melted again and is then applied with a warm knife blade to the cracks and splits in a horse's hoof just as a glazier works with his putty, the hoof having previously been carefully cleansed. The mass hardens so that it will allow of nails being driven into it.

Artificial Gum Solution (according to Kayser).—Prepare caseine by heating milk with some tartaric acid whereby, as is well known, the caseine is separated. If large quantities are desired coagulated skimmed milk can be taken and treated as is customary in the manufacture of cheese. Over the caseine thus obtained, pour a solution of 6 parts of borax in 100 parts of water and heat gently, stirring the while, whereby solution is effected. Such a proportion of borax solution is added that only small quantities of caseine remain undissolved. The clear fluid thus obtained possesses a great adhesive property, is cheap and durable and may be used everywhere.

To Nickel-plate Wood.—In order to electro-plate wood with nickel, it is necessary first to coat it with a thin stratum of metal. To effect this we prepare the following three solutions: I. Dissolve in 10 parts of sulphide of carbon 1½ parts of rubber and add to the solution 4 parts of melted wax. In a second bottle prepare a mixture of 5 parts of phosphorus, 60 parts of sulphide of carbon, 5 parts of oil of turpentine and 4 parts of asphalt powder and add this, stirring in the meantime, to the first solution. II. Prepare a solution of 2 parts of nitrate of silver in 600 parts of water, and III, a solution of 1 part of chloride of gold in 600 parts of water. The object to be coated with nickel, to which the connecting wires have been attached, is placed in solution I and after taking it out dry the whole. Then pour over it the second solution, until the surface assumes a dull, metallic appearance. It must then be rinsed in water and treated in the same manner with the third solution. The wood has now acquired a yellowish color and is ready for electro-nickel plating. The nickel bath consists of 500 parts of ammonio-nickel sulphate, 50 parts sulphate of ammonia, and 10,000 parts of water. The fluid must be neutral.

Wood Putty for Filling Cracks, Knots, and Holes in Wooden Objects.—I. Prepare a stiff mass from washed chalk and linseed oil, or still better, varnish. Some add to this mixture pieces of newspaper, which must however first be steeped in water. II. 56 parts of linseed oil and 32 parts of umber are boiled together vigorously and 1 part of yellow wax added to the hot mixture; finally, knead into the mixture, while still warm, 44 parts of chalk and 88 parts of white lead. III. Mix together 2 parts of rye flour, 1 part of pulverized lime and enough linseed oil varnish to make a kneadable mass. IV. Boil 1 part of good glue in 14 parts of water and with the partly cooled mass mix 1 part each of moistened sawdust and ground chalk. V. 2 parts of yellow wax and 1 part of rosin are melted together in a crucible and when the melting is effected add, while stirring, 2 parts of finely powdered burnt ocher. When this mixture is completely melted, pour it, while still hot, into the cracks and holes to be puttied up. The surplus is removed, when cold, with a double-beveled chisel. This putty becomes very hard and perfectly withstands moisture and heat. VI. Take well-pressed cheese mass (according to the quantity of putty required) press it out with a wooden knife and mix it, to begin with, with about the twentieth part of soft, slaked lime. If the mass does not become fatty, add more lime, stirring constantly, but each time only a small quantity, until the mass becomes yellow and fatty and can be easily spread. Such putty is very durable.

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